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VICTORIA CABRERA SITE: A MIDDLE STONE AGE SITE AT OLDUVAI GORGE, TANZANIA.

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Abstract:

Olduvai Gorge (Tanzania) is a key site for the study and comprehension of human evolution in East Africa. However, the origin of *Homo sapiens* and the Middle Stone Age have been poorly understood in the Gorge thus far. In this study, we present the dating, taphonomic, technological and typological analyses of the lithic industry and faunal remains excavated at the Victoria Cabrera Site (VCS) during the 2017 fieldwork season. The stratigraphic sequence of the site contains several levels of fluvial origin, some of them with lithic and faunal remains. Most remains (lithics and bones) are affected by rounding processes. Infrared stimulated luminescence (IRSL) dating has provided ages between 90-70 ka BP for these layers that can be related to the Marine Isotope Stage 5a. Lithics are scarce and the dominant raw materials are Naibor Soit quarzite and basalt, followed by phonolite, chert and quartz as the most common raw materials. The lithic technology is based on the production of flakes obtained from prepared cores, with the discoid method and, to a lesser extent the Levallois method being the most frequently used. The retouched blanks are described as “substratum” or “domestic” tools (sidescrapers, notches or denticulates). There is just one heavy duty piece and points are absent. The faunal assemblage includes *Alcelaphinae*, *Antilopinae* and *Equidae*. The major parts of the unidentified faunal remains are size 3 ungulates, followed by carcasses of size 2 and size 4 species. We cannot relate lithic and bones because no cut marks or percussion marks have been identified and carnivore action is scarce. In sum, VCS represents the first accurately dated Middle Stone Age site, with lithic and faunal remains in Olduvai Gorge.

Key words: Middle Stone Age, Lithic, Fauna, Olduvai, Tanzania

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1. Introduction.

Olduvai Gorge has been known on merit as the Cradle of Humankind since 1959, when Mary and Louis Leakey discovered the *Zinjanthropus* (*Paranthropus*) skull in the FLK site. Since that time, several research teams and projects have devoted considerable effort to the paleoanthropological, cultural and behavioural knowledge of the first figures of genus *Homo*: the Oldowan and the Acheulean. However, little attention has been paid to upper beds in Olduvai Gorge, as well as to the origin of our species and its material culture.

Olduvai Gorge is located in the South-eastern Serengeti (northern Tanzania), in the great East African Rift (Fig. 1). The erosion of the Olduvai River, cutting through a plain amidst a line of volcanoes in the South—e.g. Sadiman, Lemagrut, Olmoti or Ngorongoro—and lower-height metamorphic reliefs in the North—like Olongoidjo or Watumi—generated the gorge (Uribelarrea, 2014). The structural landscape remained stable until the Ngorongoro Collapse 2.2 Ma, whilst the plain was affected by external processes (weathering, and fluvial and aeolian sedimentation). Following the basin sedimentation, the

Olduvai River eroded the plain generating the gorge we know today, split into the Main and Side Gorges. Throughout that process, an intense tectonic activity as well as further basin sedimentation took place, generally by volcanic processes during the Middle and Late Pleistocene. Thanks to their low-energy sedimentary conditions, the availability of water sources and the primary sources of lithic raw material, the spot was the perfect place for the occupation of the territory by hominin groups. Such an assertion is contrasted with the more than 120 sites and the remains of four hominin species discovered (*Paranthopus boisei*, *Homo habilis*, *Homo ergaster/erectus* and *Homo sapiens*). Nowadays, the gorge geology can be split into seven beds (Hay, 1976).

Bed I (2.1Ma) in Olduvai Gorge has been well-known since the 1930s. Bed I deposits contain an important amount of sites bearing hominin fossil remains and archaeological assemblages (including fauna and lithic remains) that seem to belong to the first representatives of our genus (*Homo*) as well as to other contemporary hominin species (*Paranthropus boisei)* (Leakey, 1971, Uribelarrea, 2014, Domínguez-Rodrigo et al., 2007, 2010, Barboni et al., 2010). Oldowan and Acheulean industries have been discovered in Bed II in sites (e.g. BK or SHK) in association with remains of *Homo erectus* (Ashley et al., 2014, Domínguez-Rodrigo et al., 2013, Uribelarrea et al., 2014). Beds III and IV have provided more than 40 Acheulean sites (Leakey and Roe, 1994). After that, the Masek Bed was deposited while the great faults affect the gorge move (Leakey and Roe, 1994, Hay, 1976). This Bed represents the sedimentary clogging of the basin. At this juncture, around 0.6 and 0.4 Ma, the first fault movement happened, together with the movement of the five faults affecting the gorge. The result is the creation of the Olbalbal depression—in the east of the gorge—and the creation of the Olduvai River itself, which begins in Lake Ndutu and flows into the newly created depression. This marks the start of Olduvai Gorge due to the exposition of the above-mentioned deposits on account of the erosive process (Hay, 1976, Uribelarrea, 2014). The levels of Ndutu and Naisiusiu Beds will be deposited above them.

The Middle Stone Age (MSA) has been defined by the knapping of prepared cores, especially the Levallois-type and, above all, by retouched pieces, particularly projectile points associated to *Homo sapiens* (Clark, 1988; McBrearty and Books, 2000, Basell, 2013). Stratigraphically, the MSA in Olduvai falls within the Ndutu Bed, which consists principally of tuffaceous, aeolian, fluvial and colluvial deposits, which are deposited in the final stage of the gorge formation and, which cover the eroded areas by the Olduvai River itself (Hay, 1976). Research on the human occupation of this Bed has been discontinuous and biased in the three most relevant lines of research: chronology, human remains, and archaeology.

One unsatisfactorily resolved issue for Bed Ndutu is its chronology. The initial approach was carried by Hay, who considered that Upper Ndutu might be in the range of 60-32 ka BP, and Lower Ndutu in the range of 60-400 ka BP (Hay, 1976: 152), although he used indirect methods to this end. Manega (1993) is without a doubt, the researcher who has devoted the utmost efforts to discover the chronology of the Ndutu Bed. According to his research, on the basis of the Single Cristal Laser Fusion (SCLF) technique, Upper Ndutu might be located in a range between 210 ± 20 ka BP and 450 ± 40 ka BP and using amino acids around 260-500 ka BP. Manega dates the start of Bed Naisiusiu in 42 ± 10 ka BP by using SCLF. The latter runs counter to Skinner's dating for the same Bed, which was dated in 62 ± 5 ka BP (Skinner et al., 2003)—and it is therefore, far older than Manega's proposal—by using ESR (electron spin resonance).

Several *Homo sapiens* remains have been found in the Ndutu Bed. The first one is OH-11, a palate and maxillary arch of *Homo sp* found on the surface in western DK and assigned to the Ndutu Bed (Hay, 1976, pp. 159, Leakey 1971, pp. 230), which presents a sturdy morphology for the modern standards (Rightmire, 1980, pp. 227). The second one is OH-1968, a skull fragment partially *in situ* in Upper Ndutu levels (Von Zieten, 2009), but whose origin and study are uncertain. The last one is OH-83, a partial calvaria partially recovered in stratigraphy in the Upper Ndutu levels, close to the PLK site (Reiner et al., 2017) and identified as *Homo sapiens*. There is no direct dating for any of them, therefore they have been placed in the chronological range proposed by Hay for Ndutu (Hay, 1976, pp. 152) with the uncertainties that, as we have seen, it presents.

The archaeological study of the Ndutu Bed has also been intermittent over the last decades, with only three previous interventions. The first paper on MSA was carried out by Mary Leakey and colleagues, and in it, two sites with MSA industry are presented (Leakey et al., 1972). Both sites were not located on the paper, tough follow-up work placed them in the localities 4b and 26 (Hay, 1976, pp. 159) without further details of planimetry or stratigraphy, one of them belonging to Upper Ndutu and the other to

Lower Ndutu (Hay, 1976, pp. 28). The lithics of both sites were presented uniformly, and in there, the presence of prepared cores (Levallois and discoid) and a few retouched tools was outlined. The most used raw material was basalt, and there was a small quantity of phonolite and quartz. The assemblages, although with due precaution, were linked to the Early MSA of Lake Eyasi (Leakey et al. 1972).

The second project related to the MSA was directed by A. Mabulla, co-author in this study, from the University of Dar es Salaam in collaboration with the University of Florida between 1989 and 1990 (Mabulla 1990). Several localities shedding light on lithic and fauna find-spots were explored—none of them in stratigraphy except for locality 26 (Ndutu type site according to Hay, 1976).

The third research project was led by M. Eren during the course of the 2013 field season and was the most intense study conducted so far. They carried out a systematic survey between the second fault and the Olbalbal depression, besides other selective surveys in the junction of both gorges, resulting in the discovery of 72 find-spots which provided 521 MSA flaked pieces, as well as some faunal remains (Eren et al., 2014).

Even though the two first projects had already made it clear that the Ndutu Bed reported having occupations belonging to MSA, certainly after the work of M. Eren's team, the extraordinary potential which Olduvai Gorge has for the first modern humans in northern Tanzania became clear.

In this paper, we present the first results of Victoria Cabrera Site (VCS), which is the first site in stratigraphy with radiometric dating and several stratigraphic levels with lithic industry and faunal remains found in Olduvai Gorge.

2. Victoria Cabrera Site.

Victoria Cabrera Site (VCS) is located on the South side of Olduvai Gorge, at the junction between the Main and the Side gorge. It is on the same hill as DS, 70 meters due East of it and over 600 meters from FLK Zinj (Fig. 1). It was discovered by one of us (JMMF), along with Manuel Domínguez-Rodrigo in the course of the 2016 survey work, and it has been dug in two seasons during February and July 2017. It could not be excavated in 2018 as the site suffered an act of vandalism in which some "vandals" opened the site without official permission, exposing the stratigraphic profiles.

The works carried out so far have consisted of opening a 24 x 2m linear trench on the hillside, as well as a 9 x 2m trench transversal to the former. Both of them have exposed a Lower Ndutu stratigraphy made up of several levels, six of them containing lithic industry corresponding to the MSA and faunal remains.

Following the geologic order of formation, the following five stratigraphic levels have been identified at VCS Trenches 1 and 2 (Fig. 2):

Level 5, silty tuffaceous claystone

Level 5 is a < 120 cm reddish brown sandy and silty tuffaceous claystone. This level can be interpreted as an overbank deposit, formed in decantation facies, highly contaminated by tuffaceous deposits. In Trench 1, the uppermost section of the level contains a higher tuffaceous content and has been named Level 5a.

Level 4, Very coarse to medium sand

Level 4 is a >30 cm thick greyish very coarse to medium parallel-stratified sand (20.50% very coarse sand, 20.60% coarse sand, 21.30% medium sand). Level 4 is interpreted as a fluvial bedload level, deposited in a constant and relatively high velocity regime. Similar deposits can be found currently in the bank deposits of Olduvai River. Horizontal sets extend over 1 m, part of a fluvial bar, yet to be described in detail. In Trench 1, Level 4 appears more massive, and no sedimentary structures are observed, probably due to the degree of weathering suffered.

Level 3, Tuff breccia with sandy matrix (debris flow)

Level 3 is a yellowish matrix-supported breccia, composed by heterogeneous angular tuff clasts from 2 cm of diameter to blocks over 20 cm, and most probably eroded from upper Bed I tuffs. The matrix is brownish yellow tuffaceous sand (77.38% sand) with a considerable amount of fines (10.08% silt, 12.60% clay). The level has an erosive base, eroding the uppermost section of underlying Levels 4 and 5. Level 3 is lost eastwards due to present-day erosive processes. Size and angular shape of tuff blocks, with provenance most likely from Bed I marker tuffs which are seen eroded by these deposits in Trench 1, indicate very short transport.

Level 2, Sandy gravel

A greyish sandy gravel (66.90% gravel, 29.53% sand), very washed and clean (<5% silt and clay), lies over a channelled erosional surface, pinching out towards the East and West in Trench 2 and towards the North and South in Trench 1 (Fig. 2). Trough cross-stratification (Gt lithofacies according to Miall, 1985) is observed in the South Profile at Trench 2 (Fig. 2). Level 2 is interpreted as a fluvial bedload deposit. A separate channel has been identified in Trench 1 and named Level 2a. In Trench 2, Level 2 contains some Bed I tuff blocks, interpreted as topples generated from the erosion of the northern river margin. Lenses of finer grained material are found in between bedding, suggesting a multi-episodic genesis.

Level 1, clayey tuffaceous siltstone

The fluvial sequence ends with Level 1, which is a < 80 cm reddish brown sandy and clayey (24.55% fine sand, 21.88% clay) tuffaceous siltstone (22.39% silt), interpreted as another low-energy overbank deposit in the floodplain. Level 1 is eroded towards the East and is discomformably overlain by Holocene deposits.

The whole sequence is overlain discomformably by Upper Ndutu aeolian sand bodies, and is being eroded, forming a gully perpendicular to present-day Olduvai River, partially infilled with Ndutu, Bed I and fluvial terrace deposits (Uribelarrea et al, this volume).

3. Methodology.

3.1. Spatial Analysis.

Total stations were used to geo-reference all remains > 2 cm. Orientation patterns of bone and lithic remains were considered to reinforce the geological reconstruction of the site and to assess the impact of post-depositional events (e.g. wind, water flows, gravity, sedimentation) on the archaeological arrangement in each of the documented levels. We used compasses and clinometers to measure the horizontal and vertical orientations of each piece of remains with a longitudinal axis at least twice of its width (Voorhies 1969, Fiorillo 1991, Alcalá 1994, Howard 2007, Domínguez-Rodrigo and García-Pérez, 2013).

Orientation data were statistically treated using the “circular” package in the R free software (http://www.r-project.org, Core R-Team, 2013). The uniformity of the different levels was statistically evaluated by combining tests that can detect isotropy/anisotropy, where significance values (p) > 0.05 indicate that the null hypothesis of isotropy cannot be rejected. Rayleigh test (Z) was used to evaluate anisotropy (Fisher, 1995), and the omnibus Kuiper (V) and Watson (U^2) tests were used to determine if the orientation of the archaeological assemblage was uniform, bimodal or polymodal (Fisher, 1995). Statistical tests are accompanied by graphical plots. The spatial information was analyzed using ArcGIS 10.4.1 (Desktop, Engine), Rose.NET (Rosediagrams) and OpenStereo (Stereograms).

Orientation analyses were conducted for all VCS levels treating bones and stone tools separately as they respond differently to post-depositional forces that can generate preferential orientation patterns (Frostick and Reid, 1983, Schick, 1984). Since data tend to be scarce in all levels, measurements were bootstrapped before performing statistical tests. A small number of permutations (replacement of 100 times) was preferred as they provide meaningful statistical results without excessively distorting the original data. Only in the case of the bone assemblage in level Tuff 2, the sample size was not large enough to provide any clear results (4 pieces. The rest of the samples included at least ca. 10 elements. Ripley’s K function was used to describe how materials occur in any specific spatial area (Domínguez-Rodrigo et al., 2017).

3.2. Faunal Analysis.

Faunal remains were assigned to taxa, size category, anatomical element, side and portion when possible. For the anatomical part representation analysis, carcasses were divided in anatomical areas: cranial (horn, cranium, mandible, hyoid and teeth), axial (vertebra, ribs, pelvis and scapula) and appendicular (limb bones). Four indexes have been used to estimate the taxonomic and anatomical abundance: number of identified specimens (NISP); minimal number of element (MNE); standardized minimal animal units (%MAU); minimal number of individual (MNI) (Grayson, 1984, Binford, 1984, Lyman, 1994). To estimate the MNE, side, landmarks and age of each identifiable specimen were considered. The size of the specimens was established according to the categories described by Bunn (1982): size 5 (over 1000 kg); size 4 (300-1000 kg); size 3 (70-300 kg); size 2 (18-100 kg); size 1 (>4.5-22 kg) (Brain, 1981).

The Spearman's rank order was used to test the correlation between %MAU and bone mineral density (Lam et al., 1999), and to test a possible correlation between %MAU and standard food utility index ((S)FUI). Following the proposal of Marean and Clerghorn (2003) we used high survival element. Length distribution was examined in order to evaluate the impact of hydraulic processes, addressing also only long bones separately, and finally long bones with green bone breakage (Domínguez-Rodrigo and Martínez-Navarro, 2012, Organista et al., 2016). Bone surface modifications were examined using 10x40 hand lenses under a strong oblique light source. Cortical surfaces were evaluated and analyzed, and as a result numerous types of modifications such as tooth marks, trampling, polished, fissures and rounding were identified (Behrensmeyer, 1978, Binford, 1981, Capaldo, 1998, Fernández-Jalvo and Andrews, 2003, Domínguez-Rodrigo et al., 2009, Pickering and Egeland, 2006).

The description and quantification of the ostrich eggshells follows the criteria stated by Collins and Steele (2017) for the study of OES flakes.

3.3. Lithic Analysis.

3.3.1. Taphonomic analysis: Knowing all the possible post-depositional processes undergone by an archaeological assemblage is essential in order to make correct interpretations. For the VCS lithic assemblage, we paid particular attention to the following alterations:

Rounding. It refers to the wear and tear of an artefact surface due to the brush of the lithic tool with other sedimentary particles, giving rise to breakages, wear, and micro-detachments (Pedraza, 1996, p. 210). It can happen because of several reasons, though it is linked to hydric phenomena where water converges with the carried load. A greater rounding could mean a greater transport. It is important to take into account the transported sediment as well (Shackley, 1978). We have classified the rounding into three categories: not very intense, intense, and very intense.

Pseudo-retouch. It refers to a mechanical alteration affecting the surface of the lithic material. After Sieveking (1976) it provokes an alternating and denticulated edge and the scars have variable sizes. Other scholars note the random scars distribution of no fixed orientation or size (Tringham et al. 1974: 192) It is usually provoked by the stone movement in the sediment because of trampling or hydraulic processes (Stapert, 1976). The analysis of this kind of alteration has focused on the dispersion in the vertical direction (Courtin and Villa, 1982, Hughes and Lampert, 1977, Trigham et al., 1974, Gifford-González et al., 1985), on its relationship with the use-wear (Levi-Sala, 1986) and on the creation of pseudo-tools (McBrearty et al., 1998). We have classified the pseudo-retouch into three categories: marginal, deep and very deep.

3.3.2. Techno-typological analysis:

The term technology is understood as a conceptual approach to the material culture of the various human groups (Inizan et al., 1996, p. 13). The ultimate goal of this sort of studies is to investigate human behaviour through the study of technical, social or symbolic behaviours (Inizan et al. 1996, p. 14).

To carry out this kind of research, we analysed the *chaîne operatoire* understood as a sequence of acts, gestures, and tools constituting a technical process with a roughly predictable series of steps (Karlin, 1992, p. 109; Karlin et al., 1992, Audouze and Karlin, 2017). From an empirical viewpoint, it is defined as joint operations converging towards a single objective, whereas at the structural level it is defined as a combination of technical factors, which materialize into technical schemes. Thus, the *chaîne operatoire* only goes as far as explaining the use of a core/blanks when several blanks and cores have been exploited by following the same method, and these are then grouped into operational schemes that make up the lithic technical subsystem of a site (Audouze and Karlin, 2017).

The lithic industry studies pursue two different approaches: a quantitative approach comprising the data for each individual piece, and a qualitative approach focussed on the reconstruction of the operational schemes (Karlin, 1992). Unfortunately, the VCS lithic assemblage is very scarce to develop the second one.

In the former, raw materials, dimensions, support, cortex, accidents, fractures, alterations, platform type, scar direction, section, morphology, technique and technological classification are recorded. In addition, if the piece was modified this is also recorded as a retouched cutting edge, as well as the sort of retouch and its typological classification. In addition, we analyse other parameters on the cores such as morphology, method, type of blank (flake/blade/bladelet) and length and width of the last and biggest blanks (after Geneste 1986, Maíllo-Fernández, 2003). Prepared knapping methods are described by different protocols: Levallois (Boëda, 1994, Boëda et al., 1990) and Discoid (Boëda, 1993, 1995, Terradas, 2003, Mourre, 2003).

3.4. Chronology.

Three samples from levels 1, 4 and 5 of Trench 2 have been collected for luminescence dating to establish a chronological record for this trench. Infrared luminescence (IRSL) on the feldspar extracts of these units has been measured at the Institute of Geography of the University of Cologne. The potassium feldspar fractions of size 180-250 µm have been used for the luminescence measurements and equivalent dose estimation. post-IR-IRSL$_{225}$ protocol (Thomsen et al., 2008). This protocol involves measurement of the IRSL signal at 225°C after a low temperature (50°C) stimulation which minimizes the effect of anomalous fading. This is the fading of the signal which can be significant over the burial time but would be negligible over the timescale of the laboratory measurements and therefore, challenging to quantify accurately. This can lead to underestimation of the age. Fading tests involving the measurement of the IRSL signal after delays of different lengths in the laboratory were carried out to determine the impact of fading (cf. Auclair et al., 2003). Also, dose recovery tests on artificially bleached and irradiated subsamples were carried out to confirm the suitability of the chosen measurement protocol. 24-36 multi-grain aliquots of each sample were measured in order to get representative natural dose distributions. The resulting data have been reduced to limit the scatter by removing individual outliers according to the outlier definition of Tukey, 1977 (values outside 1.5 times the inter-quartile-range). Following this criterion less than 10% of the measured dose values were excluded. Central Age Model (CAM, Galbraith et al., 1999) from the reduced dose distribution was used to estimate the burial dose. Environmental dose rates are based on the radionuclide activity concentration from high resolution gamma spectrometry measured at the Radioisotopes Unit of the University of Seville. An internal potassium content of 12.5±0.5 % has been assumed for the feldspar grains of the three samples. A water content of 10±5 % has been considered to cover the humidity conditions during the burial period. Total dose rates have been calculated using DRAC v1.2 (Durcan et al., 2015).

4. Results.

4.1. Spatial Analysis.

The stereographic projections and omnibus tests performed on the arrangement of lithic and bony elements show a horizontal trend and anisotropic distribution in all VCS levels (Figs. A.1 and A.2). The obtained p values < 0.05 indicate that there is not a uniform distribution along the stratigraphic sequence. The Kuiper test of uniformity, the Watson goodness-of-fit test of circular uniformity and the Rayleigh test of a general unimodal alternative suggest that the assemblage is largely oriented (Table 2). Thus, the hydraulic flows detected in the geology of the site were sufficiently intense to preferentially orient materials and cause a strong post-depositional disturbance. Most tests performed on the lithics and bones found in VCS show very similar results and levels of significance; only the osseous assemblage in level 4 indicates that the null hypothesis of uniform distribution cannot be rejected, and that the unimodal alternative is not valid in this case. This is also supported by the graphical output displayed in Fig. 2. The Ripley's K function indicates a random disposition for lithics and faunal remains in distances smaller than 200 cm, except for faunal remains of level 3 that show a regular dispersion (Figs. A.3 and A.4).

4.2. Fauna.

A total of 148 faunal remains were discovered at VCS. Attending to the NISP, Levels 4 and 3 contain the major part of the materials, followed by Levels 2 and 2a. Levels 5a and 5 have five and three remains respectively (Table 3). The identification rate at VCS is low (9.4%). Remains of *Alcelaphinae* have been found in Level 3 and 4, of *Antilopinae* in Level 2 and some belonging to *Equidae* in Levels 2, 2a, 3 and 4. In most cases it was not possible to identify the specific taxa. A fragment of *Hippopotamidae* tooth was found in Level 2, a plastron fragment of *Testudinae* in Level 5a and two remains of *Rodentia* in Level 3. A total of 35 ostrich eggshell flakes (OES) were recovered from Level 2a (NR=3) and Level 4 (NR=32). The major part of the unidentified faunal remains belongs to size 3 ungulates, followed by size 2 and size 4 species (Table 3). Large animals (size 5) are only present in Levels 3 and 4. Small animals (size 1) are scarcely represented in Level 2 (two fragments) (Tables A.1-A.4). The total MNE (n= 41) and the total MNI (n = 11) present the same distribution as the NISP (Table 3).

The anatomical distribution of elements in not homogeneous; while Levels 2 and 3 show a predominance of cranial elements (Level 2=50 %/Level 3=41.7 %), followed by axial (Level 2=33.3%/ Level 3=33.3%) and appendicular elements (Level 2=16.7%/ Level 3=25%), Level 4 contains a predominance of axial elements (50%), followed by appendicular (35.7%) and l cranial element (14.3%). Level 2a has the same proportion of cranial and appendicular elements (40 %), followed by axial bones (20%). Finally, in Levels 5a and 5 only one cranial and one piece of axial remains were found (Tables A.2-A.4). These anatomical representations indicate a predominance of low survival elements (58.2%) at VCS (Table A.5) existed at the entire sample a low positive relationship between % MAU and bone mineral density (r=0.22921; p=0.023189). This indicates a bias of the low dense portions of bones. The lack of faunal refitting indicates as well intense post-depositional disturbance.

The anatomical distribution patterns observed at VCS, especially in Levels 3 and 4, is similar to the scenario proposed by Behrensmeyer (1982) for fluvial contexts. He described three possible sources of pathways for fluvial deposits characterized by specific anatomical profiles: Pathway A with high proportions of denser and more compact elements (Teeth, mandibles, limb ends); Pathway B with the presence of the more transportable bones (rib, vertebrae, scapulae, pelvis and skulls; Pathway C with all bones available. VCS is probably the result of a combination between A and B, with the presence of the more dense and compact elements and a predominance of the lighter and more transportable bones (axial skeleton). Organista and colleagues (2017) suggest that an underrepresentation of shafts may indicate the impact of water flow during sedimentation. At VCS epiphysis fragments were found only in Level 3, including a complete metatarsal of an *Equidae* and a proximal epiphysis fragment of a metapodial that belongs to a sized-2 ungulate. The statistical analysis performed on the (S)FUI and % MAU of high survival elements indicates that there is not a correlation between the anatomical distribution and the utility index (Table A.6).

Bone fragment lengths are differently distributed among levels. Specimens smaller than 20 mm are poorly represented or absent in all levels. Specimens between 20-60 mm are abundant, especially in Levels 2, 3, 4 and 2a. The amount of remains larger than 100 mm is remarkable in Level 5, but very low in the rest of the levels at VCS (Fig. A.5). Some previous works relate the scarcity of small bone fragments with water transport (Schick, 1984, Domínguez-Rodrigo and García-Pérez, 2013). A total of five complete bones were found, in Level 4, including an astragalus, a thoracic vertebra, a first phalanx of a sized-2 animal, and a cervical vertebra and a metatarsal of an *Equidae*. This data, alongside the anatomical distribution patterns observed, reinforce the idea that water transport played an important role in the final arrangement of site. A total of 32 remains present signs of green bone breakage, while only 8 bones show signs of dry fracture. In Levels 4 and 2a two bones fractured by the action of carnivores were found. No bones show a combination of green and dry bone breakage. Green bone breakage is more common among long bones (NR=27), however it was also identified in some flat bones (NR=5). The absence of small bone fragments, together with the complete lack of faunal refitting, support the hypothesis of VCS faunal arrangement as the result of water flow (Domínguez-Rodriguez et al., 2012, Domínguez-Rodrigo and García-Pérez, Organista et al., 2016).

Considering the small sample size of the assemblage all remains were used to infer the taphonomical history of VCS. No atrophic modifications were identified in any of the levels. Only four pieces bearing tooth marks have been identified, two in Level 4, one in Level 3 and one in Level 2a. In Level 4 remains of a sized-3 ungulate, including a vertebra that presents a crenulated edge over the spinous process and a metacarpal affected by pitting, were found. Carnivore traces were also found in Level 4 (a sized-3 ungulate mandible with two pits) and in Level 2a (a femur that presents a pit on the diaphysis and over the edge of the fracture). The identification of marks inflicted by carnivores at the site impedes from ruling out their contribution to the assemblage. However, the low carnivore modification rate suggests that carnivore activity was, in any case, moderate.

Post-depositional modifications are common in all levels. The most abundant are rounding and polished (Table A.7), that affect 42.6% and 33.3% of the bone remains at VCS, respectively. Although the abrasion, polish and rounding could be produced by plant roots, soil chemistry or hyena gnawing (Domínguez-Rodrigo et al., 2007), the high percentages observed in all levels, and the presence of micro-abrasion, indicate the action of water flows, especially in Levels 2a and 2. In Level 2a a rib fragment of a size-5 individual presents a complete black coloration with a high degree of mineralization. Besides, these remains present a high grade of subaerial weathering and a type of fossilization completely different to the rest of the materials of the level. This might indicate that during the formation of the level, some faunal remains were incorporated by the erosion of ancient beds and that these remains do not belong to the original assemblage in Level 2a.

The Ostrich eggshell sample shows conchoidal fractures (Kandel, 2004; Kandel & Conard, 2005), unlike natural processes. Ostrich (*Struthio camelus*) could be identified in Level 4 (*sensu* Dauphin et al. 1996). After sieving, three different refittings have been identified in Level 4. *Struthio sp*. is present in Level 2a, but proper species could not be identified. All eggshells of Level 2a are affected by water abrasion and moderate polishing; whereas 78,9% of the sample in Level 4 shows signs of microabrasion and moderate polishing. No heating changes have been identified in any level.

Several terrestrial (*Limicolaria martensiana catharia*, *Succinea baumanni*, *Gittenedouardia* cf. *hanningtoni*, *Euonyma percivali* and *Haplohelix cf. lateaperta*) and freshwater mollusc species (*Biomphalaria pfeifferi* and *Bulinus tropicus/truncatus*) have been identified in VCS (Fig. A.6 and Table A.8). Only two of them have previously been reported in Olduvai stratigraphy: *Limicolaria martensiana catharia* and *Bulinus tropicus/truncatus* (Rowson, 2017: 10). The mixture of two mollusc communities indicates that transport or reworking of the material must have occurred, although the distances travelled could have been short. Most of the terrestrial species reflect an open, sparsely vegetated area analogous to the contemporary habitat in the Olduvai area. Large shrubs or scattered trees would have been present, and the area was probably at least as well vegetated as today (Rowson, 2017: 11).

4.3. Lithic Analysis.

Lithic industry has been recovered from six levels at VCS. The lithic assemblage is not very abundant; it is composed of 99 pieces, eight of which are retouched and 9 are cores. The small sample size of the different levels does not allow a technological study of the collection (Table 4). Notwithstanding, the lithic sample provides important qualitative information to frame the occupation by Anatomically Modern Humans (AMH) in Olduvai Gorge.

4.3.1. Taphonomic results:

The number of pieces in each level is very scarce, which can distort the rounding and pseudo-retouch results. In broad terms, lithic tools found in every level present some rounding alteration, which is consistent with the fluvial formation of the site. The levels most affected by rounding are level 2 with the 34.4% and level 2a with 100% of the remains. Which is no surprise due to their high energy fluvial origin. Levels 4 and 5 present rounding alteration on some part of the assemblages, 32% and 50% respectively, although the intensity of the rounding was lower than on levels 2 and 2a (Fig. A.7a). This can be attributed to the low energy fluvial nature of the site. Level 5a do not present modifications. However, this could be related with the due to the small number of remains recovered.

Pseudo-retouch affects 20 to 44% of the pieces in a low-intense way (Fig. A.7b). We deem the fluvial agent to be responsible for most of the rounding and pseudo-retouch of the pieces, and we should bear in mind—except for Level 2a that the energy of the altering agent and the displacement of the parts does not seem very intense.

4.3.2. Techno-typological results:

From a techno-typological point of view, only general comments can be made because of the sample size:

The raw materials used in the site are naibor quartzite (56%), basalt (29%), phonolite (14%), quartz (1%) and chert (1%) (Fig. A.8).

Naibor quartzite comes from the Naibor Soit, a Precambrian inselberg 3,5 km North to the site. This quartzite is almost entirely made up of crystallized quartz, it looks very much like mineral quartz and responds to knapping in a similar way (Rubio-Jara et al., 2017, pp. 4).

The basalt comes from Lemagrut volcano, 10-12 km South to VCS. The acquisition of this raw material may have been obtained in palaeochannels from Lemagrut or from the Side Gorge, as in the lower Beds of Olduvai Gorge (Jones, 1994).

The closest phonolite source to Olduvai Gorge originates in the Engelosen, 7 km North to VCS. It is a hill made up of "flow banded nepheline phonolite lava, slightly porphyric, dark greenish grey" (Hay, 1976, pp.12). It comes in slabs and, despite being of good quality for knapping, it could be affected by flow banding (Jones, 1994, pp. 257).

Chert is of the highest quality and easy to find in the current riverbed, but it is appear as cobbles of irregular and small morphology, which makes it exceedingly difficult to knap prepared methods (Levallois/discoid).

Quartz is pretty scarce in the studied collection and can be obtained in the Olduvai riverbed itself.

Level 2: Level 2 contains the largest lithic assemblage at VCS: 32 pieces were recovered from this level. Four of them are cores, and four are retouched. Quartzite is the most common raw material (63%), followed by basalt (31%), and phonolite (6%) (Table 4 and Table A.9). Blanks are divided into cortical flakes, a tested block of raw material or ordinary flakes. There are seven discoid flakes (three of them being cordal and three having a centripetal direction) and three Levallois flakes, which have been obtained using different methods: preferential, bipolar and centripetal (Fig. 3: 2-8).

There are four retouched pieces (Table A.15): two denticulates (one of them in basalt and the other one in quartzite), a notch in quartzite (Fig. 3: 7), and a heavy-duty piece (core-axe) in basalt (Fig. 3: 1).

The cores are two centripetal (not discoid), one unifacial in basalt, one bifacial in quartzite, one polyhedral in basalt, and another unipolar core (single-striking platform) in basalt, also indicating that blanks were obtained from not-prepared cores (Table A.16).

Level 2a: this level has 16 pieces—10 of the in basalt and the remaining six in quartzite (Table 4 and Table A.10). There are no retouched blanks but there is a core. Over half are ordinary flakes (9/16), but the assemblage also includes two discoid flakes (cordal and centripetal), and a preferential Levallois flake (Fig. 4: 6-8). The core is polyhedral-type and it was knapped in quartzite (Table A.16).

The retouched piece is a denticulate-endscraper in quartzite on an ordinary flake (Fig. 4: 8 and Table A.15).

Level 3: A total of 15 pieces have been found in this level: 11 of are quartzite blanks and four were knapped in basalt (Table 4 and Table A.11). Besides, there is an ochre fragment without evidence of use. There is only one discoid flake with centripetal direction. The remaining blanks are ordinary flakes (8/16), chunks and undetermined pieces. The only core present at the level is a unifacial discoid core in quartzite (Table A.16).

Level 4: 23 stone tools have been recovered from Level 4; 65% of them are made in quartz, followed by phonolite (22%). There is also a piece of basalt, a piece of quartz, and another of chert (4% each). Four of the pieces clearly come from prepared cores: a *desbordant* flake in quartz, a preferential Levallois flake, and a *récurrent* bipolar flake, the latter two were knapped in phonolite (Fig. 4: 9-11). There is also a cordal flake, probably from a discoid core also in phonolite (Table 4 and Table A.12).

In addition, one of the three cores are Levallois preferential in quartzite and the remaining two are opportunistic-type, where the natural angle ratio has been used to extract some flakes (Table A.16).

There are two retouched pieces (Table A.15). One of them is a notch in quartzite on an ordinary flake and the other is a *desbordant* flake retouched on a *déjeté* sidescraper in quartz (Fig. 4: 11, 12).

Level 5: This level contains 10 pieces: four of them in basalt, three in phonolite and three in quartzite (Table 4 and Table A.13). Seven of them are ordinary flakes, although there are two Levallois flakes—one being recurrent unipolar and undetermined-type, in basalt and phonolite, respectively (Fig. 4: 4, 5). There are no cores, and one of these pieces, the Levallois bipolar one, is retouched in simple inverse sidescraper (Table A.15).

Level 5a: this level only has three pieces, all of them in basalt and obtained by using discoid methods, as there are two flakes with a centripetal direction, and a pseudo-Levallois point, typical of this sort of exploitation (Fig. 4: 1-3, Table 4 and Table A.14). No piece presents retouch.

4.4 Chronology

The quartz fractions extracted from the three samples collected for luminescence dating were insufficient for the measurement of the natural doses and the test required to provide robustness to the method. In addition, the few measurements carried out on the quartz fractions show that their optically stimulated signal (OSL) is not dominated by the fast component (necessary requirement for blue-OSL dating). Dose recovery tests show an overestimation of the given dose by more than 50%. According to these observations, K-feldspar has been chosen as the best dosimeter in this case.

Dose recovery tests from feldspar using the pIR-IR225 protocol derive in a recovered to given dose ratio of 1.1±0.1 for given doses of 200 Gy. The fading tests yielded an average fading rate per decade (g-value) of 1.2±0.8 %. Such low fading rates have been suggested to be an artifact of the laboratory measurements (Thiel et al., 2011) and therefore no fading correction has been applied.

Dose distributions are well defined with average over-dispersion values below 25%. The low scatter in the distribution suggests that these samples are not affected by incomplete bleaching.

Total dose rates, estimated burial doses and derived ages are summarized in Table 1. Results show that deposition of these sediments occurred between 70 and 90 ka BP. This can be related to the Marine Isotope Stage (MIS) 5a, associated to the first warm phase of this MIS.

5. Discussion.

The archaeological remains from VCS are too scarce to hold a deep discussion about the role of the site in the regional MSA. Still, its study allows the formulation of some working hypotheses related to its stratigraphic position and the palaeo-environment conditions, as well as to its lithic industry.

The geological record at VCS, dating back to around 75-86 ka BP, is a Lower Ndutu fluvial terrace deposit (Uribelarrea et al., in this volume), just prior to Upper Ndutu sedimentation, which can be approximately dated 90 ka BP. This is a slightly older chronology than that suggested by Hay (1976) and far from those proposed by Manega (1993).

Based upon chronology, we place VCS within MIS 5a (90-75 ka BP). Bearing in mind that Olduvai Gorge is located in a transition zone between eastern Africa and tropical Africa, and that climate changes are asynchronous and regional in Africa (Bloome et al. 2012, Sturchio et al., 1993., Scholz et al., 2007), we should be cautious when talking about paleoclimatic conditions with the analytical conditions we currently have. The fauna found in the site does not provide any paleoclimatic information. Only the study of gastropods could indicate a plant covert? similar to the current one.

Cobo-Sánchez et al. (2014) proved that anisotropy can be detected in autochthonous assemblages under certain conditions (e.g. lacustrine environments) and where no transport processes can be detected. Orientation patterns were used to detect the autochthony of VCS' archaeological assemblages, as isotropy is associated with the lack of post-depositional transport processes. According to our results, the assemblage was transported, as the remains are significantly oriented, as expected from a fluvial context.

Also, the analysis of faunal remains found at VCS indicates that the assemblage was mainly the result of water flow transport. Besides, lithic remains show evidences of intense fluvial transport at levels 2 and 2a, and low fluvial transport at level 3 and 4. This supports the interpretation of faunal anisotropy due to hydraulic flow on an autochthonous assemblage. The absence of anthropogenic modification on any sense does not permit to related directly faunal and lithic remains. However, the predominance of rounding indicate that they were deposited and transported by fluvial processes, although it should have happened separately. Carnivore activity, although secondary, was the main biotic agent. This conclusion is in line with the skeletal part representation, predominated by the presence of the axial skeleton, and the absence of small fragments of bones, refitting and long bone epiphyses. This pattern also corresponds to assemblages affected by hydraulic processes.

The MSA in northern Tanzania is defined by a number of industries from very few sites. It was proposed by Mehlman (1989) and is synthesized in the Table 5 and Fig. 5. From a chronological point of view, VCS would be coetaneous at the beginning of the Kisele industry (Mehlman, 1989). This industry is identified from Mumba Unit VI and levels 12-17 and 18-25 from Nasera rockshelter. Chronologically, it is located between 73/63 ka BP for Mumba VIa—dated by using OSL— and 56 ka BP for level 17 of Nasera—dated by using U-Th—(Mehlman, 1989, Gliganic et al., 2012) although Mehlman puts it off until 90 ka BP (Mehlman, 1989, p. 560). Kisele Industry is characterized by a smaller industry than the one before (Sanzako from Mumba VIb), by a high presence of retouched points and bifacial pieces, as well as by prepared cores methods (Levallois/discoid) and a low presence of heavy duty and bipolar methods (Mehlman, 1989).

The industry prior to Kisele in the local sequence of the MSA is Sanzako, and it is only located in Mumba Unit VIb (Mehlman, 1989), and by using Th-230 the dating result is 131,710 (+6,924 -6,026) and Pa-231 measures to 109,486 (+44,404 -23,020) (Mehlman 1989, Brauer and Mehlman, 1988). This industry is characterized by prepared cores methods, especially discoid, a low proportion of bipolar methods, points and bifacial points, and a higher presence of domestic-type pieces: scrapers, notches and denticulates (Solano-Megías, 2018).

Although, the lithic industry found in VCS is very scarce and makes it impossible to compare it directly with industries which are sort of synchronous. From a general point of view, VCS levels are characterised by the flake production from prepared core methods (Levallois and particularly discoid), the absence of bipolar methods and points of any type, and a limited presence of retouched blanks—being the existing ones domestic-type (sidescrapers, denticulates and notches). Heavy duty is also present. Besides, the overall percentage of retouched pieces is 8%, although in levels with retouched pieces (Levels 2a, 2, 4 and 5) it ranges from 6.25% to 17.3%. Thus, as a result of the data presented, VCS should be related to the beginning of the Kisele industry. The site with the closest chronology to VCS is Unit VIa from Mumba rockshelter, which approximately dates from 73-63 ka by using OSL (Mehlman, 1989, Gliganic et al., 2012). However—and stressing again how flimsy the collection is—from a qualitative point of view, VCS seems to be more akin to the oldest industry (Sanzako) than to its contemporary (Kisele), even though this conclusion is tentative until the larger area of the site is excavated. Under no circumstances can VCS be associated with the Sangoan/Early Middle Stone Age of Lake Eyasi, as was the case in the past for Olduvai surface collections (Leakey et al, 1972, Eren et al. 2014). As a result, we consider the above-ground evidence of MSA in Olduvai Gorge to correspond to several temporary moments rather than to a number of Early MSA assemblages.

6. Conclusions.

Victoria Cabrera Site is the first site which clearly belongs to the Middle Stone Age with a stratigraphic and chronological control in Olduvai Gorge. Six levels from the site—dating back between 75 to 86 ka BP—contain lithic industry which, despite being small-numbered, is characteristic for prepared core methods, especially discoid and Levallois, with some "domestic-type" retouched pieces (sidescrapers, denticulates and notches), scarce heavy-duty, and a total absence of points. Lithic industry and fauna have been found together, though the association between them is not clear yet.

The site corresponds to MIS 5a, a period of climatic favourable conditions. However, neither the paleo-environment features of that time—as Olduvai Gorge is on the border between eastern Africa and tropical Africa characteristics— nor the asynchronous and local climate changes in the area (Blome et al. 2012) can be characterised in detail yet.

Only a few sites that belong to the MIS5 period have been found in East Africa (Mirazón-Lahr and Foley, 2016, pp. 223). One explanation might be related to the absence of investigation and dating of deposits.

The site of VCS adds to the list of other sites with levels corresponding to MIS5, such as Mumba, with the expectation that more knowledge about the human presence, patterns of settlement, mobility of human groups, and interaction with the ecosystem in Olduvai Gorge and northern Tanzania can be gained.

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To Victoria Cabrera-Valdés (1951-2004), *In Memoriam*.

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CAPTIONS

Table 1: Summary of luminescence dating from VCS including the depth and water content used for calculation of the environmental dose rate. A 5% error has been added to the assumed water content. Estimated equivalent doses derived from IRSL measurements and corresponding burial ages, expressed in kiloyears (ka).

Table 2. Omnibus statistical tests applied to the different archaeological levels of VCS, divided by bones and lithics

Table 3. NISP, MNE and MNI by taxa and weights size category at archaeological levels of VCS.

Table 4. Blanks' *chaîne opératoire* inventory by levels at VCS.

Table 5. Northern Tanzania MSA's sites cited in the text.

Figure 1. a) Map of Africa; b) Map of Tanzania; c) Map of Olduvai Gorge; d) Location of Victoria Cabrera site (VCS). ©google maps.

Figure 2. Figure 2. 1. Victoria Cabrera Site Trenches 1 and 2 stratigraphic profiles. 2. Schematic stratigraphical correlation between Victoria Cabrera Site Trench 1, Trench 2 South Profile and Trench 2 West Profile. 3. South Profile picture.

Figure 3. Lithics from Level 2: 1. Heavy-duty (core-axe) on basalt, 2-4. Cordal flakes on quartzite, 5. Centripetal discoid flake on basalt, 6. Recurrent Levallois flake on basalt, 7. Preferential Levallois flake on quartzite (notch), 8. Bipolar Levallois flake on quartzite.

Figura 4. Lithics from VCS: 1-3: Level 5a; 4-5: level 5; 6-8: level 2a; 9-12: Level 4. 1. Centripetal discoid flake on basalt, 2. Pseudolevallois point on basalt, 3. Centripetal discoid flake on basalt, 4. Unipolar Recurrent Levallois on basalt, 5. Ordinary flake on basalt, 6. Preferential Levallois flake on basalt, 7. Centripetal discoid flake on basalt., 8. Ordinary flake on Quartzite (denticulate), 9. Preferential Levallois flake on basalt, 10. Bipolar levallois flake on basalt, 11. Desbordant flake on quarzite (sidescraper), 12. Ordinary flake on quartzite (notch).

Figure 5. Map of Northern Tanzania with the major sites cited in text (source NASA).

Appendix A.

VICTORIA CABRERA SITE: A MIDDLE STONE AGE SITE AT OLDUVAI GORGE, TANZANIA.

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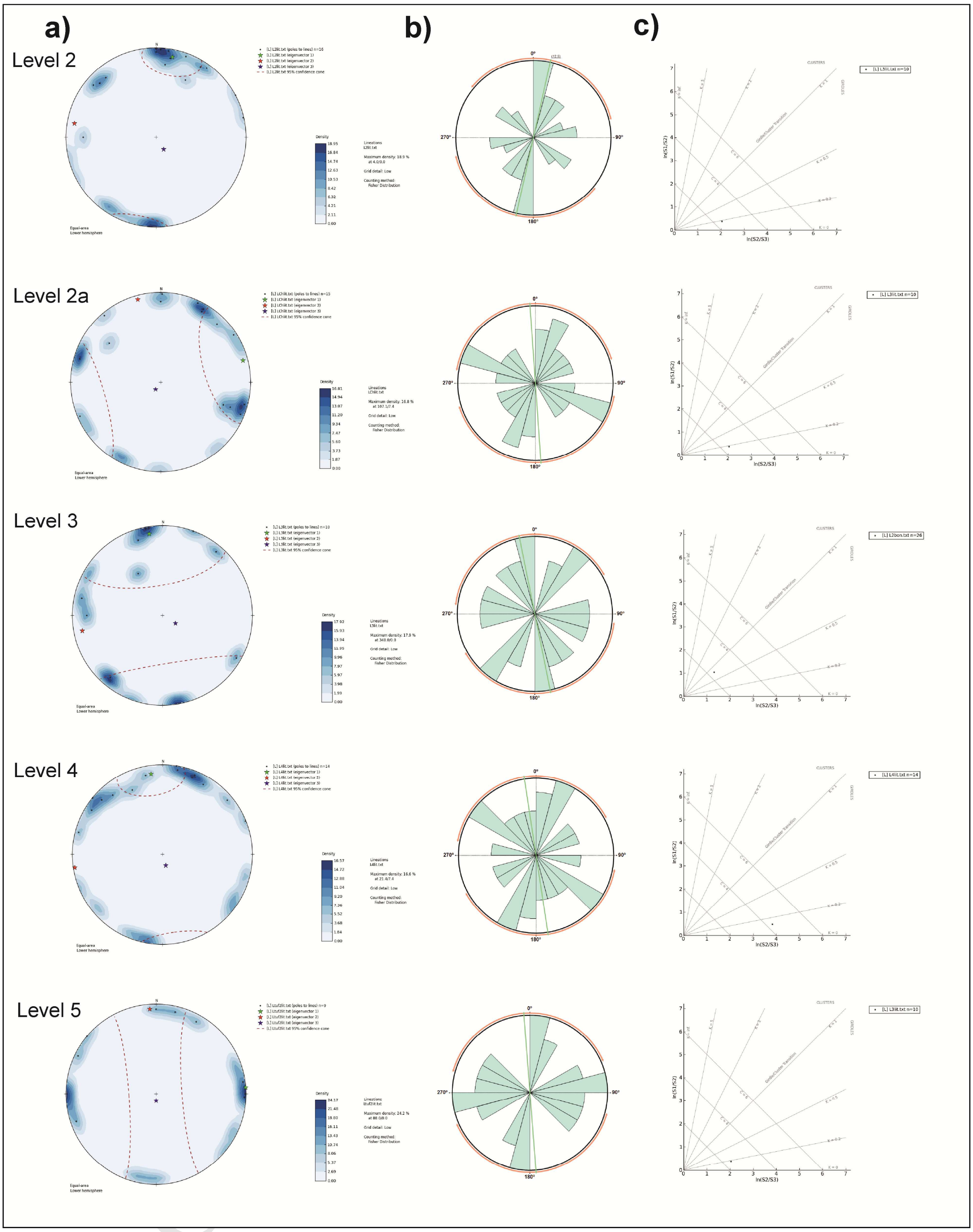


Figure A.1. a) Rose diagram showing lithic orientation; b) Stereogram showing the azimuth orientation of lithic specimens with a longitudinal axis from BK5. The first eigenvalue comprising most of the inertia is presented here, as well as the confidence interval of the mean trend/plunge orientation (in red); c) Woodcock diagram with von Mises distribution K.

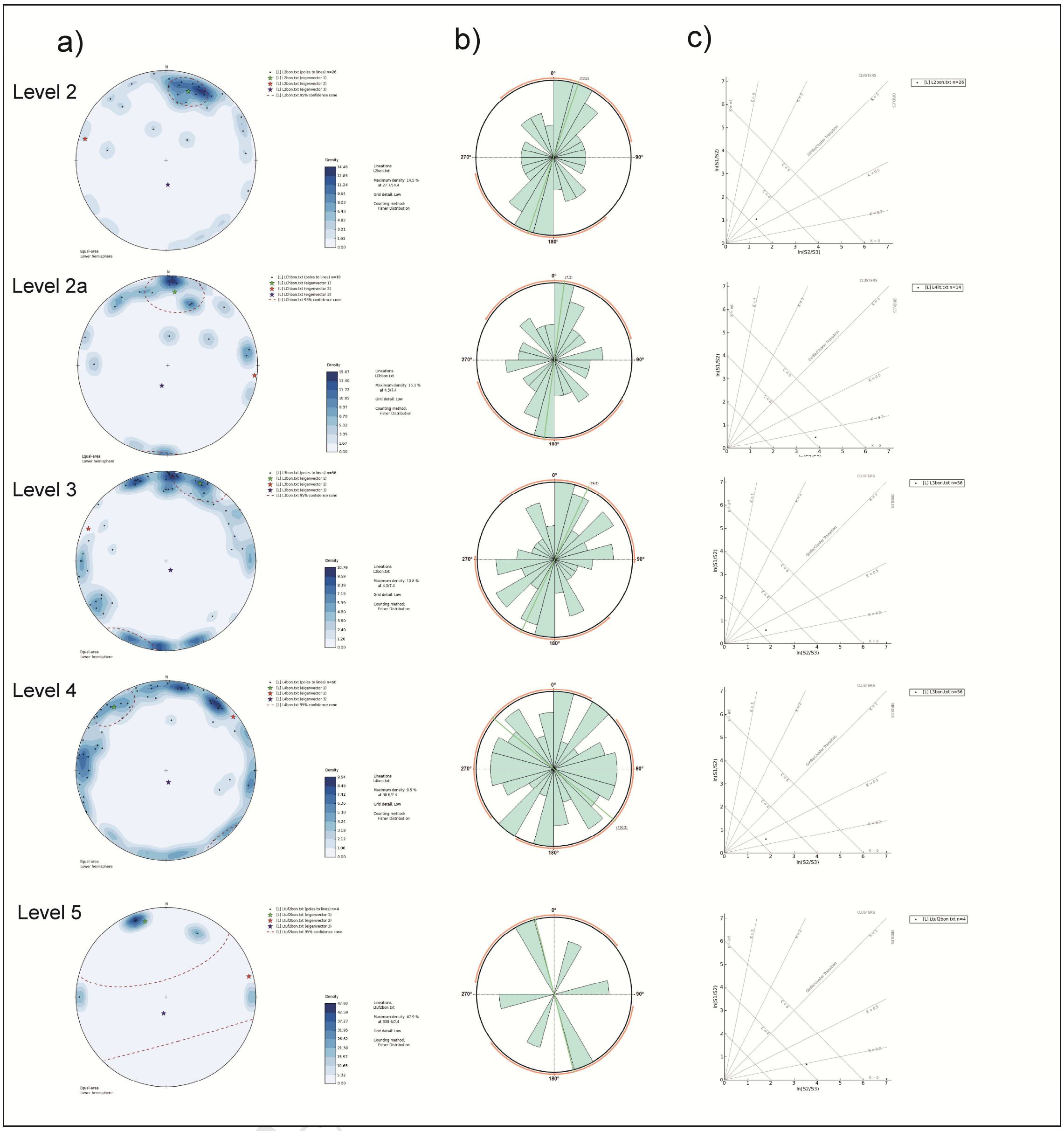


Figure A.2. a) Rose diagram showing bones orientation; b) Stereogram showing the azimuth orientation of lithic specimens with a longitudinal axis from BK5. The first eigenvalue comprising most of the inertia is presented here, as well as the confidence interval of the mean trend/plunge orientation (in red); c) Woodcock diagram with von Mises distribution K.

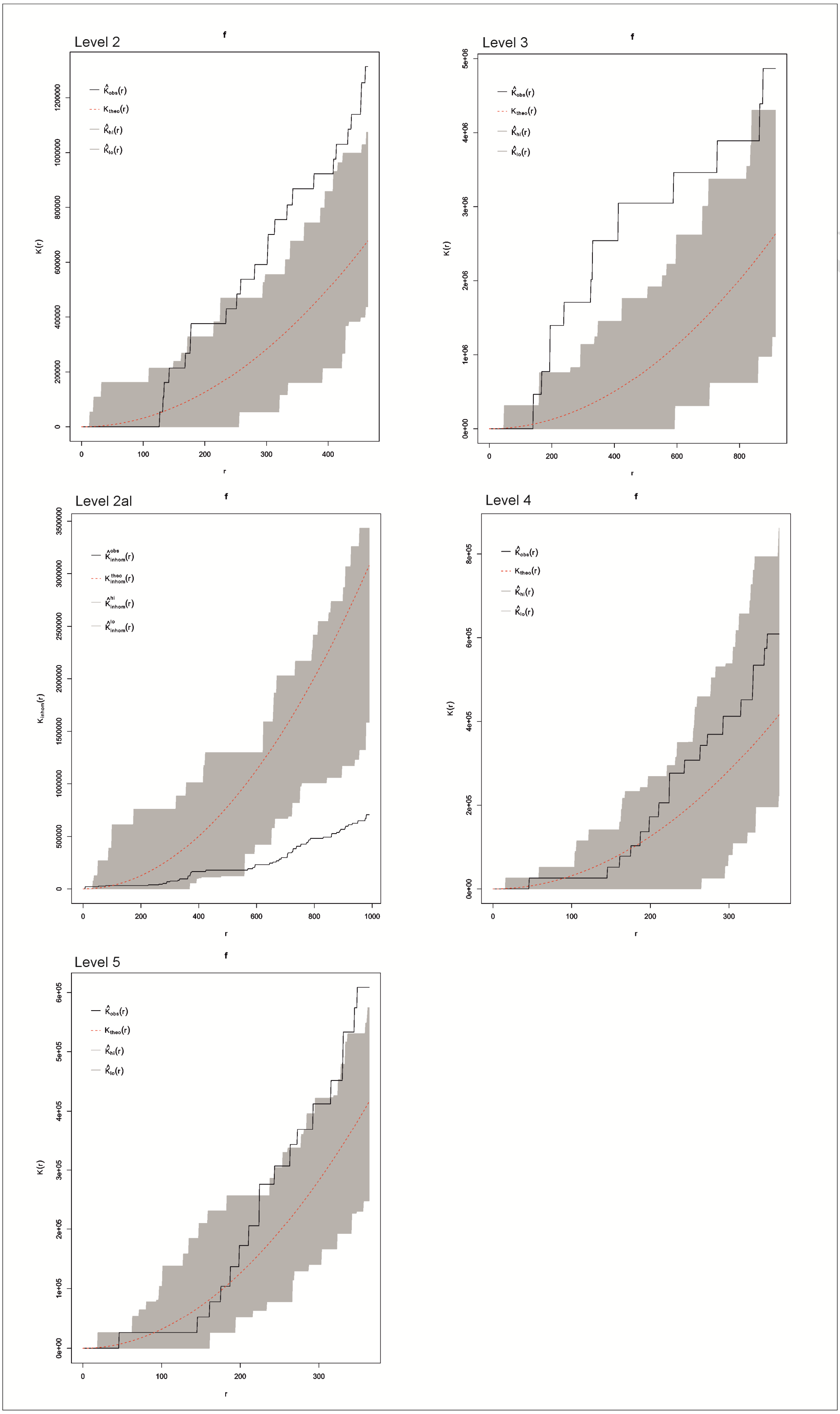


Figure A.3. Ripley's K function for lithic assemblages.

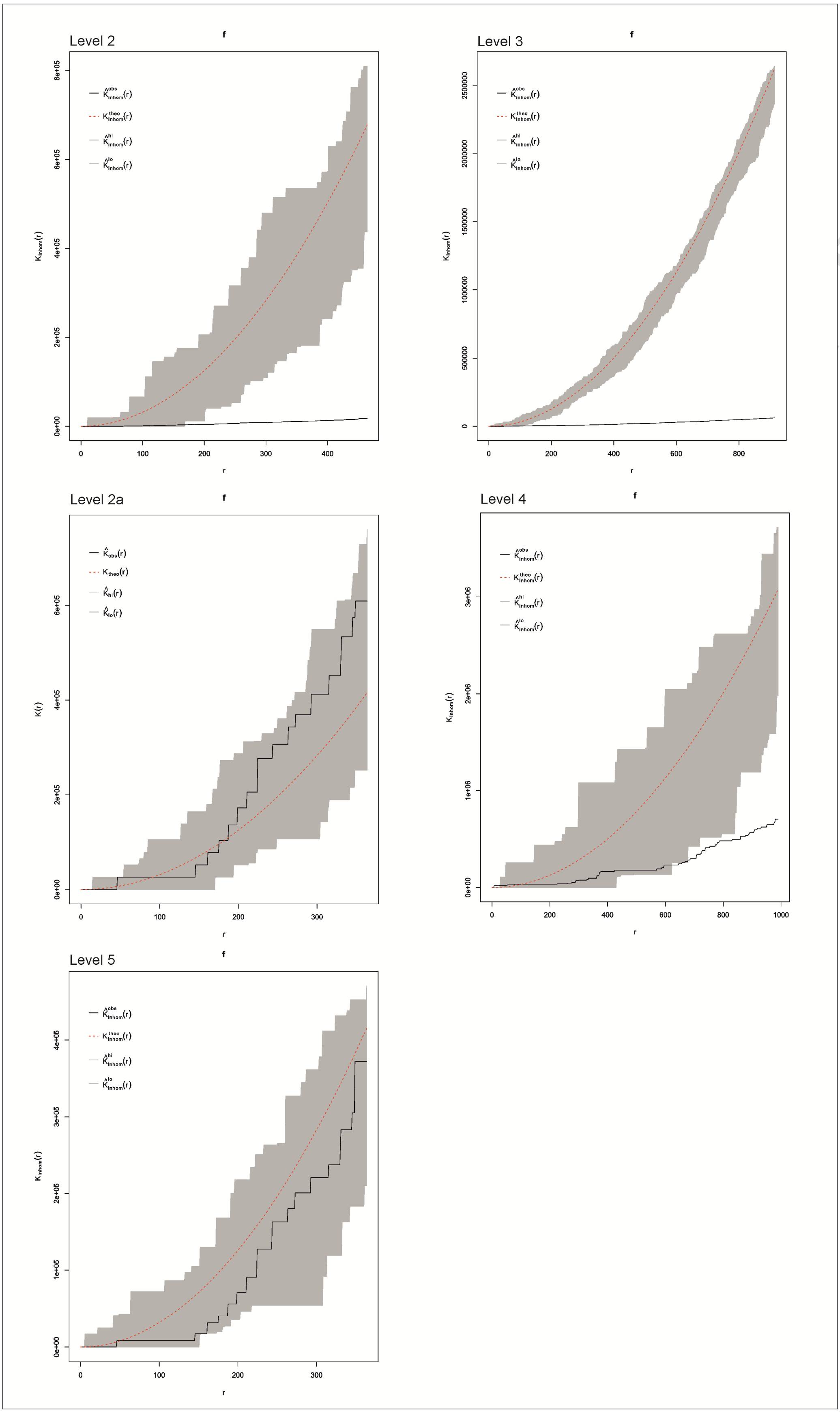


Figure A.4. Ripley's K function for bone assemblages.

NISP (MNE)	Size 5			
	Level 2	Level 3	Level 4	Level 2a
Isolated teeth	1 (-)			
Rib	1 (1)	2 (1)		1 (1)
Flat			1 (-)	

Table A.1. NISP and MNE by anatomical element for Size 5 animals.

NISP (MNE)	Size 4				
	Level 2	Level 3	Level 4	Level 2a	Level 5
Cranium	1 (1)				
Mandible		-2			
Isolated teeth		6 (-)		1 (-)	
Vertebrae		1 (1)	2 (2)		
Rib			1 (1)		
Metacarpal				1 (1)	
Tibiae		1 (1)			
Metatarsal		1 (1)			
Long	1 (-)	2 (-)	1 (-)		
Flat	3 (-)		2 (-)	1 (-)	1 (-)

Table A.2. NISP and MNE by anatomical element for Size 4 animals.

NISP (MNE)	Size 3				
	Level 2	Level 3	Level 4	Level 2a	Level 5
Cranium		3 (1)	1 (1)		1(1)
Mandible	1 (1)	1 (1)	1 (1)	1 (1)	
Isolated teeth					1 (-)
Rib		2(1)	1 (1)		1 (1)
Scapula		1 (1)			
Coxa		1 (1)			
Radius		1 (1)			
Ulna		1 (1)			
Metacarpal	1 (1)		2 (1)		
Femur					1(1)
Long	2 (-)	3 (-)	4 (-)	2 (-)	
Flat	1 (-)	4 (-)	4 (-)	1 (-)	

Table A.3. NISP and MNE by anatomical element for Size 3 animals.

NISP (MNE)	Size 2			
	Level 3	Level 4	Level 2a	Level 5a
Vertebrae		1 (1)		
Rib				1 (1)
Scapula	1 (1)	1 (1)		
Coxa		1 (1)		
Radius			1 (1)	
Metacarpal	1 (1)	1 (1)		
Femur	1 (1)			
Astragalus		1 (1)		
Phalanx		1 (1)		
Long	6 (-)	2 (-)	2 (-)	

Table A.4. NISP and MNE by anatomical element for Size 2 animals.

NISP / %NISP	Level 2	Level 3	Level 4	Level 2a	Level 5a	Level 5
Axial cranial skeleton	3/50%	10/41.7%	2/14.3%	2/40%	2/50%	1/50%
Axial postcraneal skeleton	2/33.3%	8/33.3%	7/50%	1/20%	1/25%	1/50%
Appendicular bones	1/16.7%	6/25%	5/35.7%	2/40%	1/25%	0

Table A.5. NISP and % NISP distribution by anatomicaL segment.

Level	Size category	Spearman's r	p
Level 2	Size 3	-0.73259	0.10714
Level 3	Size 4	-0.25198	0.64286
	Size 3	-0.53611	0.19048
Level 4	Size 4	-0.51437	0.28571
	Size 3	-0.57735	0.25
Level 2a	Size 4	-0.57735	0.25
	Size 3	-0.15121	0.7381

Table A.6. Spearman's statistics correlation between high survival elements by level and size category and (S)FUI.

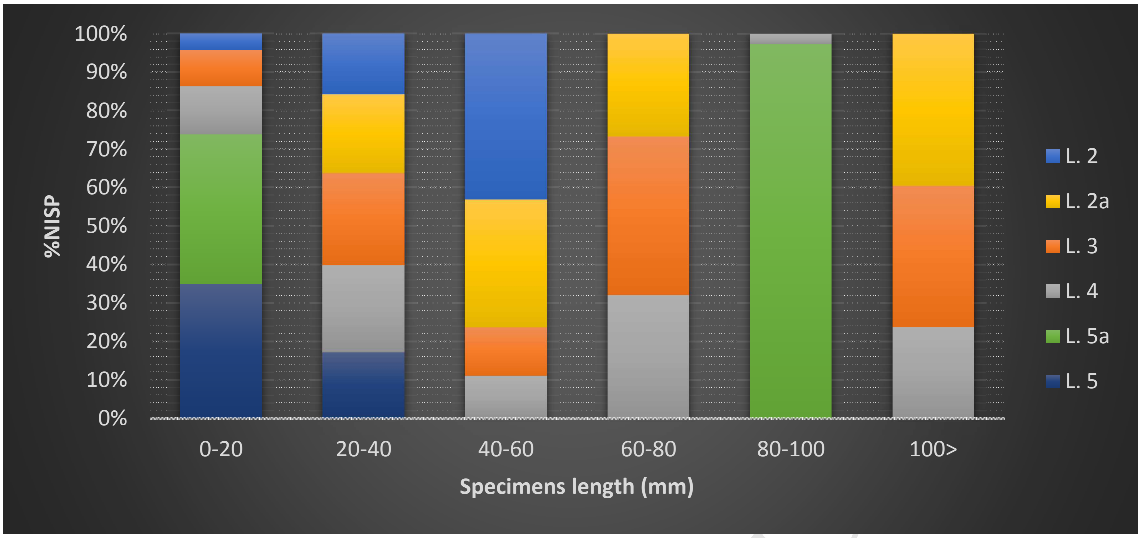


Figure A.5 %NISP distribution in function of length sizes.

NR / %NR	Level 2	Level 3	Level 4	Level 2a	Level 5a	Level 5
Rounding	16/26	21/45	20/50	10/19	2/4	0/3
	69.5%	46.7%	40%	77%	50%	0
Polished	13/26	19/45	10/50	9/19	3/5	0/3
	56.5%	42.2%	20%	69.2%	60%	0
Fissure	2/26	12/45	5/50	8/19	0/5	0/3
	8.7%	26.6%	10%	61.5%	0	0
Concretions	5/26	5/45	5/50	1/19	2/5	1/3
	21.7%	11.1%	10%	7.6%	40%	33.3%
Trampling	0/26	7/45	2/50	0/19	0/5	0/3
	0	15.5%	4%	0	0	0

Table A.7. NISP (NISP%) by archaeological level and postdepositional modification.

Genus	Species	NMI					Overall total	
		Level 2	Level 2a	Level 4	Level 5	Level 5a	NMI	%
Freshwater taxa								
Biomphalaria	pfeifferi	2		107			109	60
Bulinus	tropicus/truncatus			10		1	11	6
Total freshwater MNI		2		117		1	120	66
Terrestrial taxa								
Limicolaria	martensiana catharia	1	2	46	3	1	53	29
Succinea	baumanni			5			5	3
Gittenedouardia	cf. hanningtoni			2			2	1
Euonyma	percivali			1			1	1
Haplohelix	cf. lateaperta			1			1	1
Total terrestrial MNI		**1**	**2**	**55**	**3**	**1**	**62**	**34**
Overall total MNI		**3**	**2**	**172**	**3**	**2**	**182**	**100**

Table A.8. Material identified, minimum numbers of individuals, and percentage occurrence.

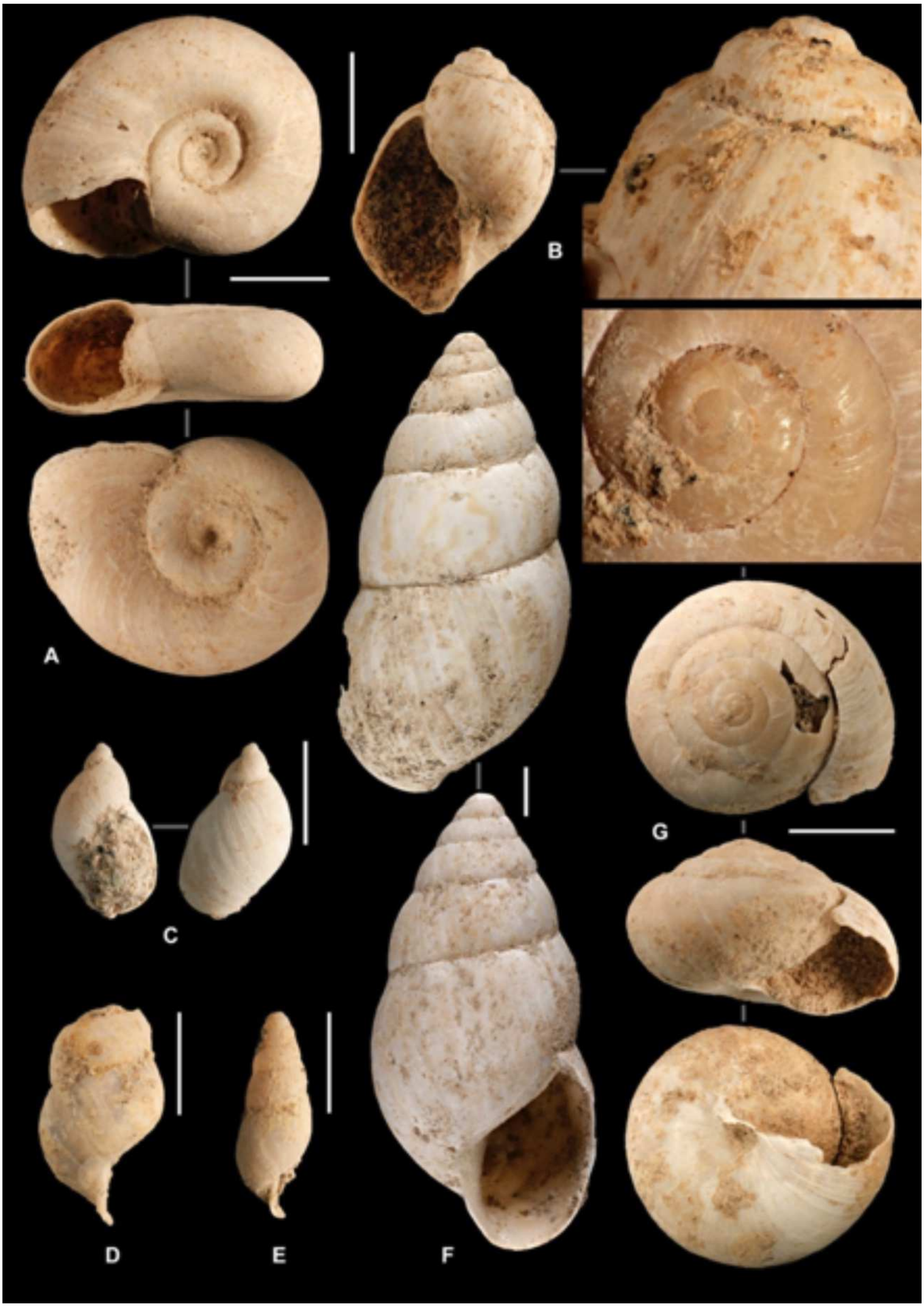


Figure A.6. Representative shells from VCS: **A**, *Biomphalaria pfeifferi*; **B**, *Bulinus truncatus/tropicus*; **C**, *Succinea baumanni*; **D**, *Gittenedouardia* cf. *hanningtoni*; **E**, *Euonyma percivali*; **F**, *Limicolaria martensiana catharia*; **G**, ?*Haplohelix* cf. *lateaperta*. All scalebars 5 mm. All shown to scale, except for F (shown at 0.5x scale) and enlargements of sculpture for B and G (Rowson 2017).

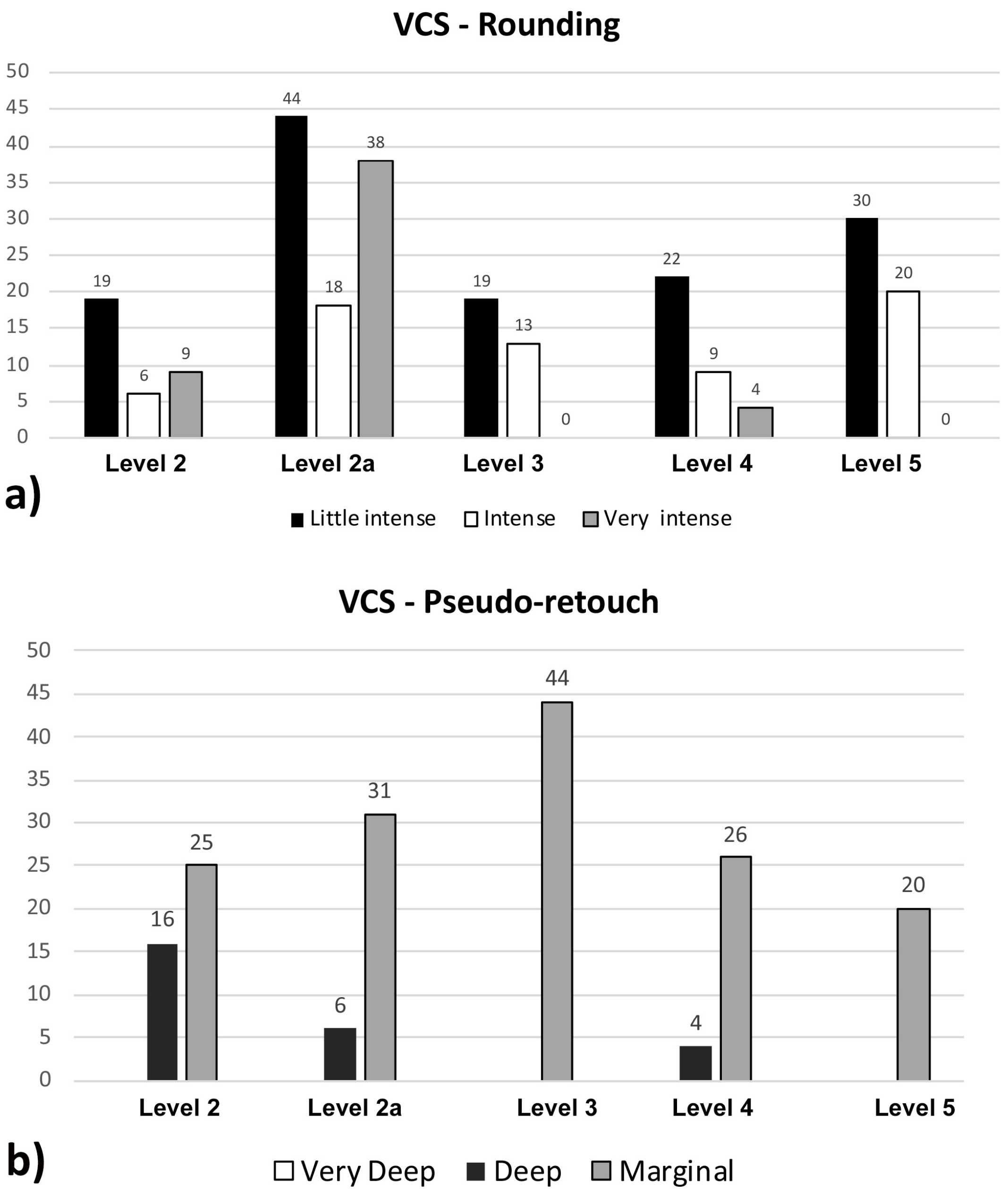


Figure A.7. Lithic alterations at VCS: a) rounding, b) pseudo-retouch.

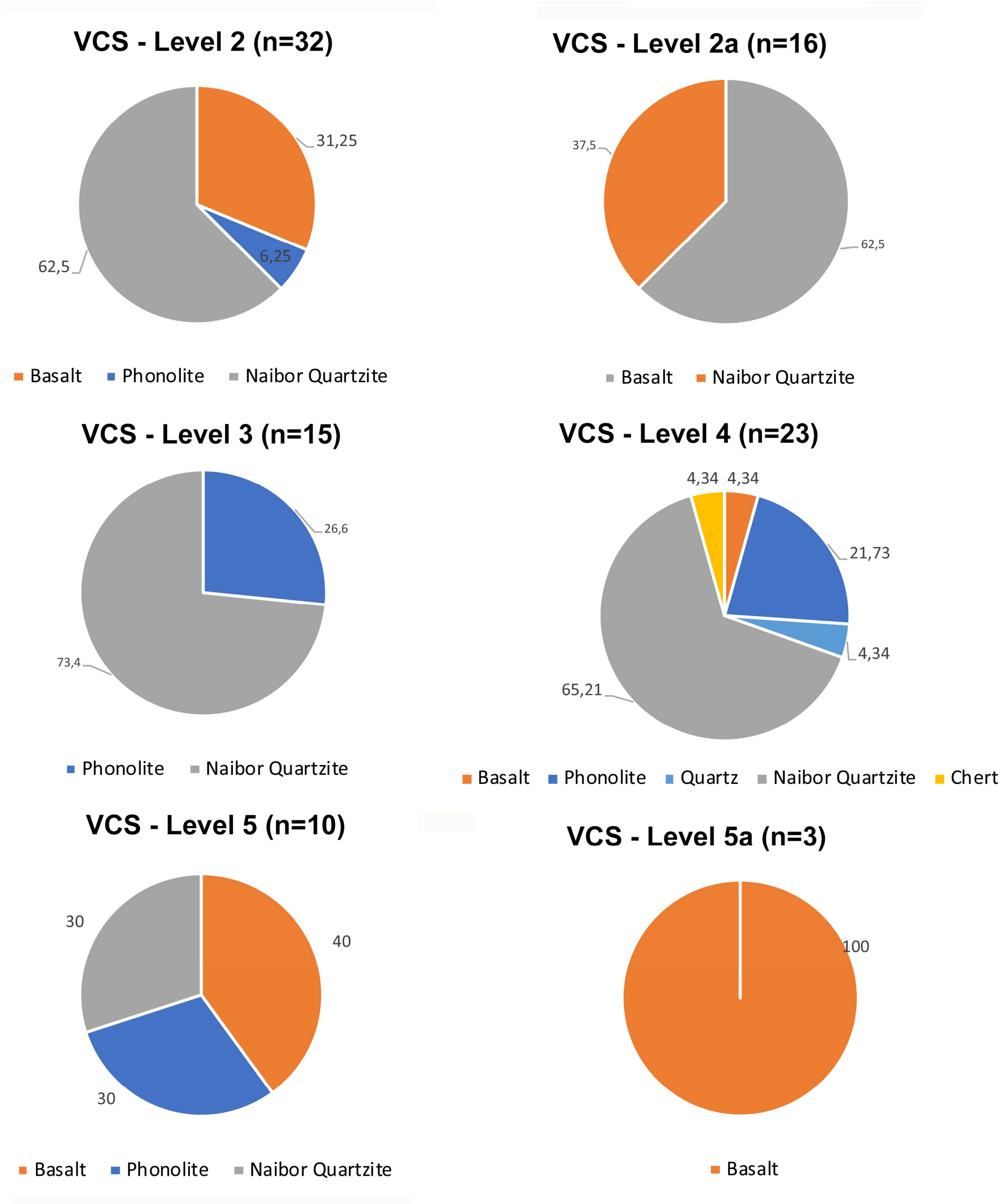


Figure A.8. Raw material by levels at VCS.

	Basalt	**Phonolite**	**Quartzite (naibor)**	**Total**
Tested cobble.	1			1
Cortical flake with no cortical platform.	1			1
Cordal flake			3	3
Desbordant flake			1	1
Striking platform preparation flake		1		1
Ordinary flake	1	1	6	8
Ordinary flake with cortex	2		1	3
Centripetal flake (discoid)	1		2	3
Cortical centripetal flake (discoid)			1	1
Levallois preferential			1	1
Levallois recurrent bipolar			1	1
Levallois (centripetal récurrent)	1			1
Core	1		3	4
Chunck	1		1	2
Hammer	1			1
Total	**10**	**2**	**20**	**32**

Table A.9: Lithic inventory by raw materials at Level 2.

	Basalt	Quartzite (naibor)	Total
Cordal flake	1		1
Striking platform preparation flake	1		1
Ordinary flake	4	4	8
Ordinary flake with cortex	1		1
Centripetal flake (discoid)	1		1
Levallois preferential	1	1	2
Blade	1		1
Core		1	1
Total	**10**	**6**	**16**

Table A.10: Lithic inventory by raw materials at Level 2a.

	Phonolite	Ochre	Quartzite (naibor)	Total
Cobble (fragment)	1			1
Ordinary flake	1		7	8
Centripetal flake (discoid)			1	1
Core			1	1
Chunck	1		2	3
Indet.	1			1
Other		1		1
Total	**4**	**1**	**11**	**16**

Table A.11: Lithic inventory by raw materials at Level 3.

	Basalt	Phonolite	Quartz	Quartzite (naibor)	Chert	Total
Cordal Flake		1				1
Desbordant flake			1			1
Striking platform preparation flake				1		1
Ordinary flake		2		6		8
Ordinary flake with cortex	1			1	1	3
Levallois Preferential		1				1
Levallois (récurrent bipolar)		1				1
Core				3		3
Chunck				1		1
Chip				3		3
Total	**1**	**5**	**1**	**15**	**1**	**23**

Table A.12: Lithic inventory by raw materials at Level 4:

	Basalt	**Phonolite**	**Quartzite (naibor)**	**Total**
Ordinary flake	2	2	2	6
Ordinary flake with cortex	1			1
Levallois (récurrent unipolar)	1			1
Levallois (indet.)		1		1
Total	**4**	**3**	**3**	**10**

Table A.13: Lithic inventory by raw materials at Level 5.

	Basalt	Total
Pseudolevallois point	1	1
Centripetal flake (discoid):	2	2
Total	**3**	**3**

Table A.14: Lithic inventory by raw materials at Level 5a.

	Quartzite (naibor)	Phonolite	Basalt	Quartz	Total
Level 2					
Denticulate	1		1		2
Heavy Duty-core axe			1		1
Notch	1				1
Level 2a					
Denticulate-endscraper	1				1
Level 4					
Notch	1				1
Sidescraper (dejeté)				1	1
Level 5					
Sidescraper inverse simple			1		1
Total	4		3	1	8

Table A.15: Retouched blanks inventory by levels and raw materials.

	Quartzite (Naibor)	Basalt	Total
Level 2			
Centripetal		1	1
Centripetal (bifacial)	1		1
Poliédrico	1		1
Unipolar	1		1
Level 2a			
poliédrico	1		1
Level 3			
Discoid (unifacial)	1		1
Level 4			
Levallois preferential	1		1
Oportunistic	2		2
Total	8	1	9

Table A.16: Core inventory by levels and raw materials.

Table 1: Summary of luminescence dating from VCS including the depth and water content used for calculation of the environmental dose rate. A 5% error has been added to the assumed water content. Estimated equivalent doses derived from IRSL measurements and corresponding burial ages, expressed in kiloyears (ka).

Sample	Lab. Code Luminescence	Lab. Code Gamma spectrometry	Trench 2 Level	Depth (m)	w (%)	Environmental dose rate (Gy/ka)	Equivalent dose (Gy)	Age (ka)
VCS-L1	C-L4535	2915	1	0.6	10	4.44 ± 0.21	334.4 ± 17.2	75.3 ± 5.2
VCS-L4	C-L4536	2916	4	0.8	10	4.26 ± 0.21	365.4 ± 17.7	85.8 ± 5.9
VCS-L5	C-L4537	2917	5	2.0	10	3.97 ± 0.20	342.3 ± 13.4	86.2 ± 5.5

	Level 2		**Level 2a**		**Level 3**		**Level 4**		**Level 5**
	Bones	**Lithics**	**Bones**	**Lithics**	**Bones**	**Lithics**	**Bones**	**Lithics**	**Lithics**
Kuiper	V: 13.8988	V: 13.738	V: 12.7429	V: 11.996	V: 11.332	V: 10.1176	V: 9.2738	V: 9.1716	V: 11.8716
	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$
Watson	U^2: 11.2854	U^2: 11.7863	U^2: 10.165	U^2: 9.5455	U^2: 4.9172	U^2: 4.2042	U^2: 3.6202	U^2: 3.8968	U^2: 8.2133
	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$	$p<0.01$
Rayleigh	Z: 0.2144	Z: 0.3436	Z: 0.2581	Z: 0.296	Z: 0.0749	Z: 0.129	Z: 0.2144	Z: 0.1469	Z: 0.2894
	p=0	p=0	p=0	p=0	p=0	p=0	p=0.21	p=0	p=0

Table 2. Omnibus statistical tests applied to the different archaeological levels of VCS, divided by bones and lithics.

Taxa/Size	LEVEL 2			LEVEL 2a			LEVEL 3			LEVEL 4			LEVEL 5			LEVEL 5a		
	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI	NISP	MNE	MNI
Alcelaphini							1	1	1	1	1	1						
Antilophini	1	1	1															
Equidae	1	1	1	1	1	1	3	2	1	1	1	1						
Hippopotamidae	1	1	1															
Testudinae																1	1	1
Rodentia				1	1	1	2	2	1									
Size 5	1	1		1	1		2	1										
Size 4	4			2	1		8	2		5	2		1					
Size 3	4	1		4	1		18			15	6		2	2				
Size 2	3			3	1		9			9	6					1	1	
Size 1	2																	
Indeterminate	9			7			2			19						1		
Total	28	5	3	21	6	2	46	8	3	59	16	2	3	2	0	3	2	1

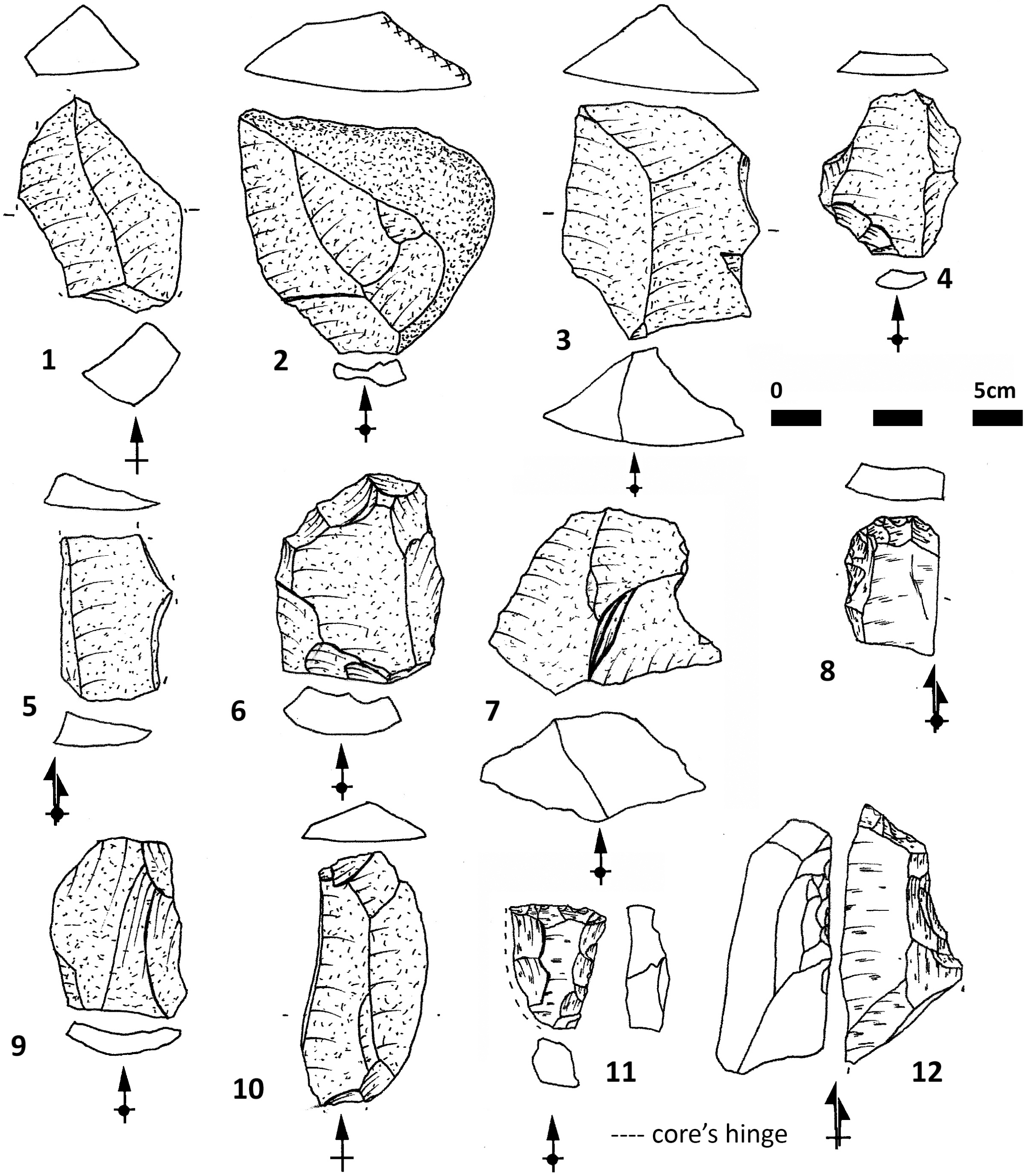
Table 3. NISP, MNE and MNI by taxa and weights size category at archaeological levels of VCS.

	Level 2	Level 2a	Level 3	Level 4	Level 5	Level 5a	Total
Phase 0: test and raw material preparation.							
Cobble			1				1
Tested cobble	1						1
Cortical flake with no cortical platform	1						1
Phase 1: Preparation							
Desbordant flake	1			1			2
Striking platform preparation flake	1	1		1			3
Pseudolevallois point						1	1
Cordal flake	3	1		1			5
Phase 2: Exploitation							
Ordinary flake	11	9	8	11	7		46
Centripetal flake (discoid)	4	1	1			2	8
Levallois (Preferential)	1	2		1			4
Levallois (unipolar)					1		1
Levallois (bipolar)	1			1			2
Levallois (centripetal)	1						1
Levallois (indet.)					1		1
Blade		1					1
Phase 4. Abandon							
Core	4	1	1	3			9
Phase 5. Divers							
Chunck	2		3	1			6
Hammer	1						1
Indet.			1				1
Chip				3			3
Other			1				1
Total	32	16	16	23	9	3	99

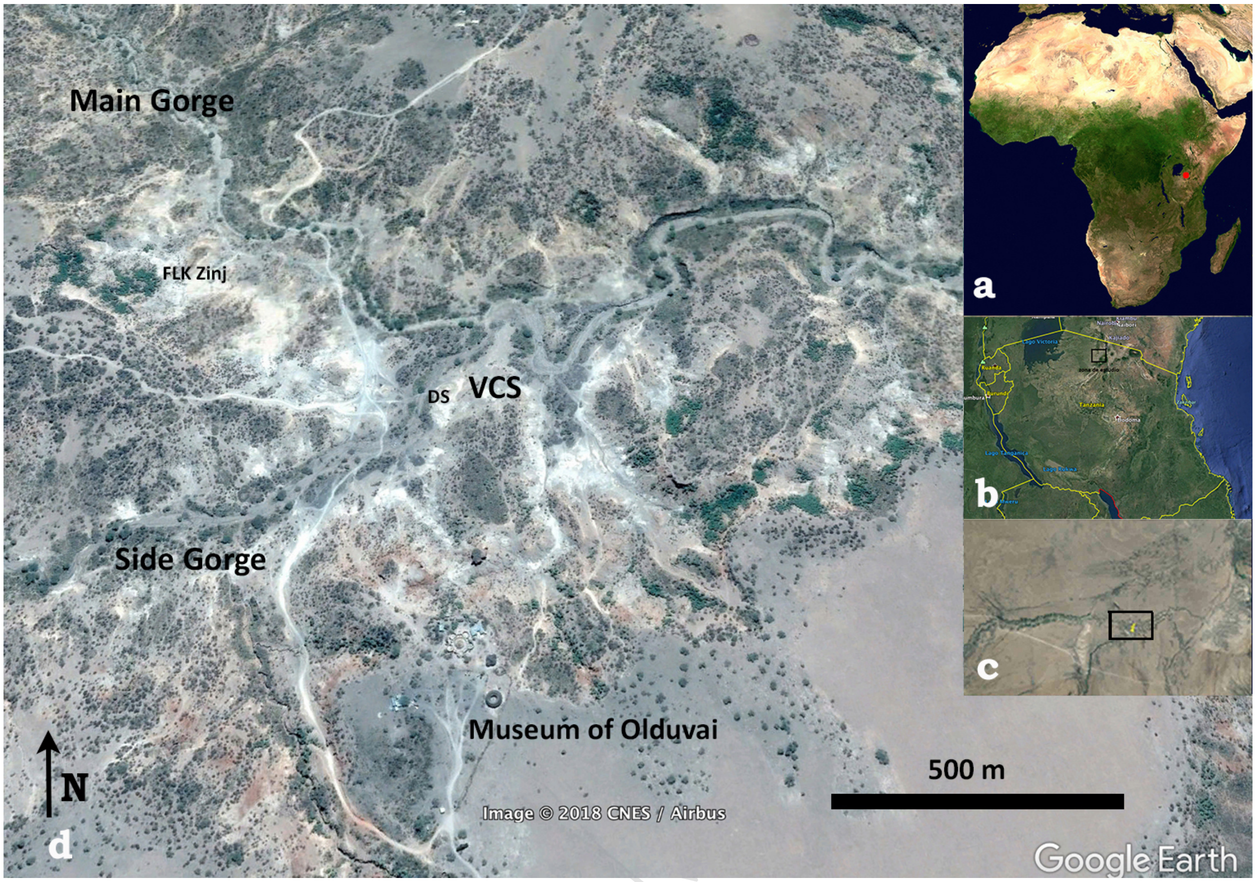
Table 4. Blanks' *chaîne opératoire* inventory by levels at VCS.

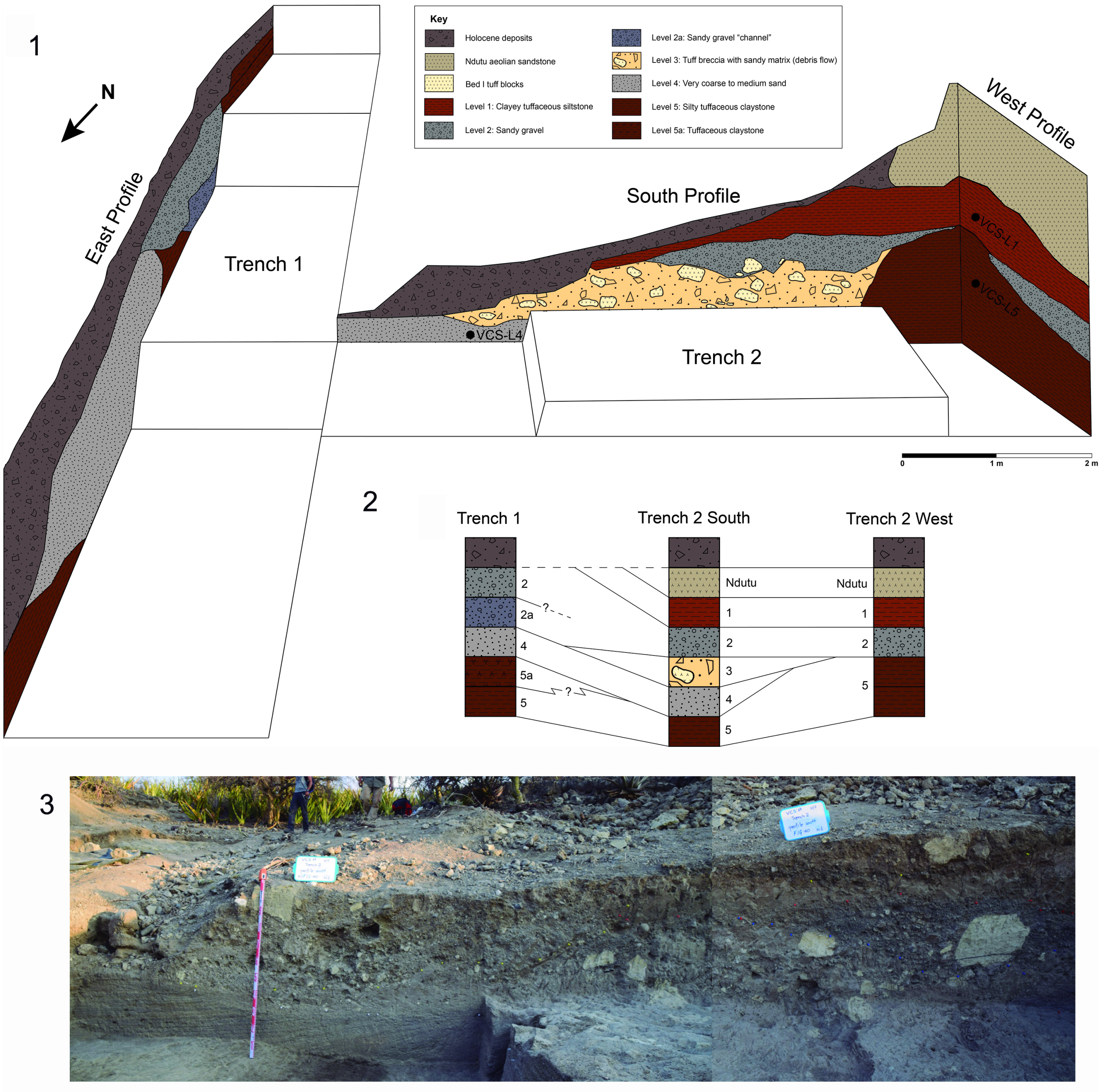
Industry	Site	Techno-Typological features	Type	Year	Chronology (Ka BP)	Bibliography
Njarasan	Eyasi Shore	Heavy Duty and scrapers Discoidal method	Surface	1935 and 1977	± 200	Mehlman, 1989
Ngaloban	Laetoli	Scrapers, heavy Duty, points (uni/bifacial) Discoidal method	Surface/pit	1998-2003	120 130-100 240-500	Hay, 1987 Manega, 1993 Manega, 1993
Sanzako	Mumba VI-B	Scrapers, bifacial pieces, Heavy Duty Discoid method	Excavation	1938	131-109	Mehlman, 1989
Kisele	Mumba VI-A Nasera 18-25 Nasera 12-17	Smaller industry Scrapers, points, bifacial pieces Discoid/Levallois methods	Excavation	1938 1975-76 1975-76	90-56	Mehlman, 1989 Gliganic et al., 2012
Loiyangalanian	Loiyangalani	Scrapers, denticulates Discoid/Bipolar methods	Excavation	1985 and 2001-2005	64	Bower & Mabulla, 2013

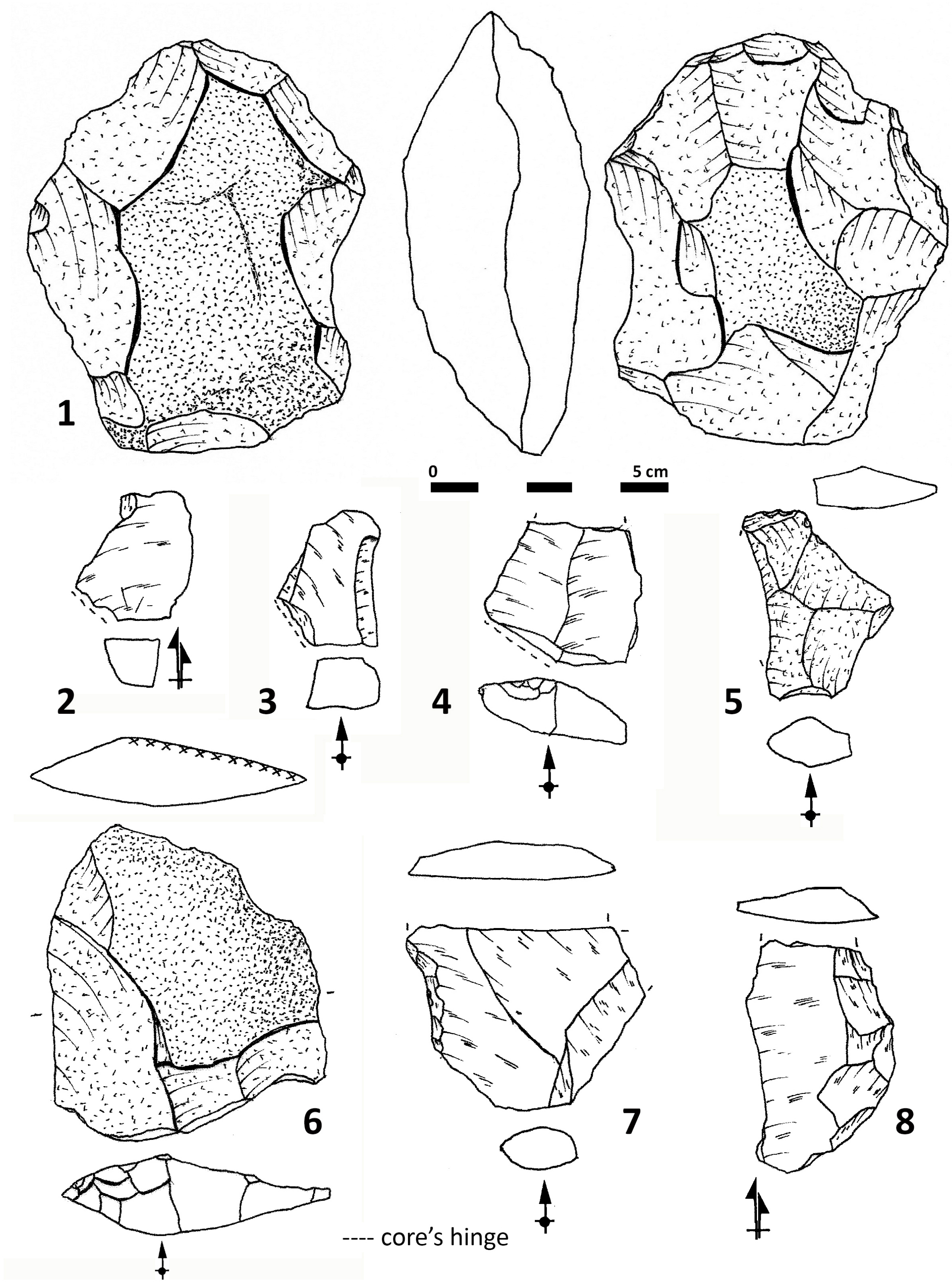
Figure 5. Map of Northern Tanzania with the major sites cited in text (source NASA).

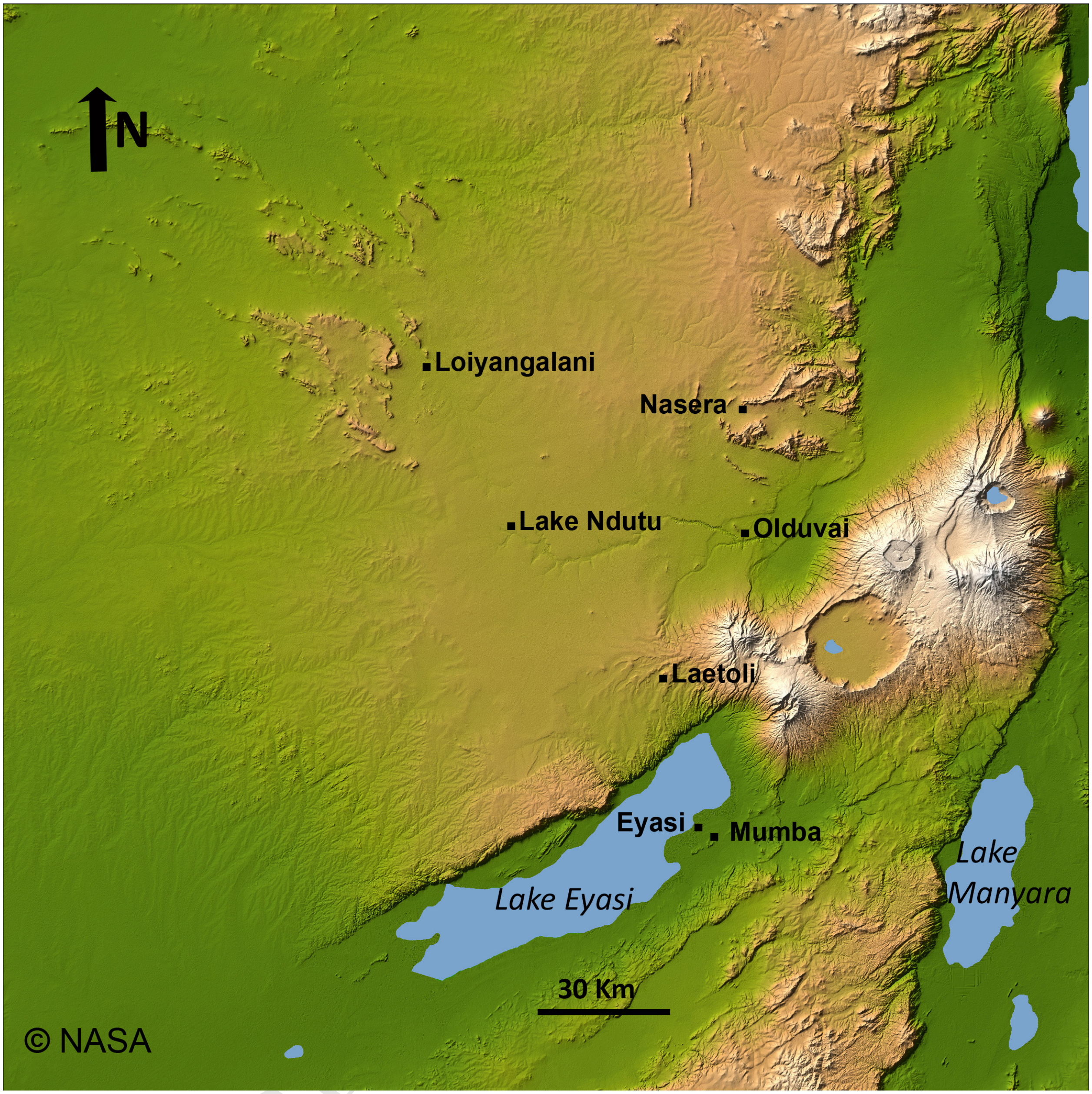


1
2
3
4
0
5cm
5
6
7
8
9
10
11
12
---- core's hinge


Main Gorge
FLK Zinj
DS
VCS
Side Gorge
Museum of Olduvai
N
500 m
Image © 2018 CNES / Airbus
Google Earth
a
b
c
d


1
N
East Profile
Trench 1
Key
Holocene deposits
Ndutu aeolian sandstone
Bed I tuff blocks
Level 1: Clayey tuffaceous siltstone
Level 2: Sandy gravel
Level 2a: Sandy gravel "channel"
Level 3: Tuff breccia with sandy matrix (debris flow)
Level 4: Very coarse to medium sand
Level 5: Silty tuffaceous claystone
Level 5a: Tuffaceous claystone
South Profile
West Profile
VCS-L1
VCS-L5
VCS-L4
Trench 2
0
1 m
2 m
2
Trench 1
Trench 2 South
Trench 2 West
2
2a
4
5a
5
Ndutu
1
2
3
4
5
Ndutu
1
2
5
3


1
0
5 cm
2
3
4
5
6
7
8
---- core's hinge


N
Loiyangalani
Nasera
Lake Ndutu
Olduvai
Laetoli
Eyasi
Mumba
Lake Eyasi
Lake Manyara
30 Km
© NASA

CONFLITC OF INTERESTS:

The authors declare that they have no conflict of interest.